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cable logging systems

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ABSTRACT

Forests, which have a great potential source of income in developing countries, can and often do provide badly needed employment opportunities for rural people.

In the recent past, and even today, tractor skidding was the logging technique mostly used in tropical mechanized logging. However, as forest development moves up to the hinterland, where the terrain is often too steep for tractor skidding, cable logging is often more advantageous, not only for productivity but also often for soil conservation. The effects of any logging system on the residual stand can have a bearing on which of any system to use.

Cable logging was primarily developed in Central Europe and introduced into and redeveloped in North Europe, North America and Japan according to their own forest conditions.

This Manual is designed to give the reader an overall picture of the different major cable logging systems being manufactured at this time and how these systems compare with each other. The most important aspect in trying to achieve this goal has been to describe all systems in a similar manner, in order that the reader can directly compare the different systems and determine which system or systems are appropriate for a given set of conditions.

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1. INTRODUCTION

FAO attaches great importance to the impact of its educational activities as a means of transferring knowledge and technology to the developing countries.

This Manual has been especially prepared for foresters, loggers and foremen in developing countries. Its aim is to make the use of cable logging systems easier and more efficient by showing the users the options available to them.

Cable logging systems have developed differently throughout the world. This is due to differences in traditions and conditions. Terrain, yarding distances, road location, tree and log sizes, labour costs and silvicultural treatments are examples of the many factors that have influenced the development of different cable logging systems in different regions of the world.

Cable logging systems from some regions of the world have been tried in other regions, sometimes with success, sometimes without. The key factor in selection is to match the harvesting system to the harvesting conditions. However, the selection of the correct system is not enough since there are usually many alternatives for any given type of logging system. Machine capabilities, such as pulling power, line speed, yarding distance, mobility etc., can vary greatly from one machine to another, and therefore it is important to select the correct alternative within a system as well as to select the proper type of machine. This is not an easy task. The variety of cable logging equipment available, plus the possibilities for modifying the application of the equipment results in a virtually unlimited number of alternatives.

It should be noted that cable systems are not always the best alternative and their use generally applies for the special conditions for which they were developed.

This Manual is designed to give a good overall picture of the different major cable logging systems being manufactured at this time, and how these systems compare with each other. The most important aspect in trying to achieve this goal has been to describe all systems in the same manner and to use the same international units of measure when giving the specification for each system. Using this as a base the reader can directly compare these different systems with each other and determine which are appropriate for a given set of conditions.

This Manual does not replace the instruction manual provided by manufacturers of cable logging systems, which should always be studied carefully, and it should be noted that machine and equipment specifications are in a continuous state of change.

The Manual has been made possible through a special contribution from Norway under the FAO/Norway Government Cooperative Programme. The main author was Mr Roy S. Larsen of Interforest AB, and the project leader Mr G. Segerström of FAO.

Any comments and suggestions with regard to modifications and improvements of this Manual will be welcome.

2. CABLE LOGGING SYSTEMS

Typical examples of major cable logging systems are shown in this Manual and the factors which affect the productivity of each system are discussed as well as their advantages and disadvantages, in order that readers can decide which cable logging system is the most suitable when planning their forest harvesting. Some actual productivity figures are given.

While there are other classifications on cable logging systems, in this Manual the classification depends on cable logging machines currently used in the world, because the Manual is designed for foresters who first have to decide what kind of machine should be used in their forests.

The following classifications have been used:

- Independent Bunching Winches
- Machine-mounted Winches
- Yarders
- Yarding Trailers for Continuous Mainline System
- Mobile Tower Yarders
- Running Skyline Swing Yarders

In addition, since many carriages for the above systems can be, and are used for more than one cable logging system classification, the various types of carriages have been described under:

- Carriages and Accessories

The above categories are described on the following pages.

2.1 Independent Bunching Winches

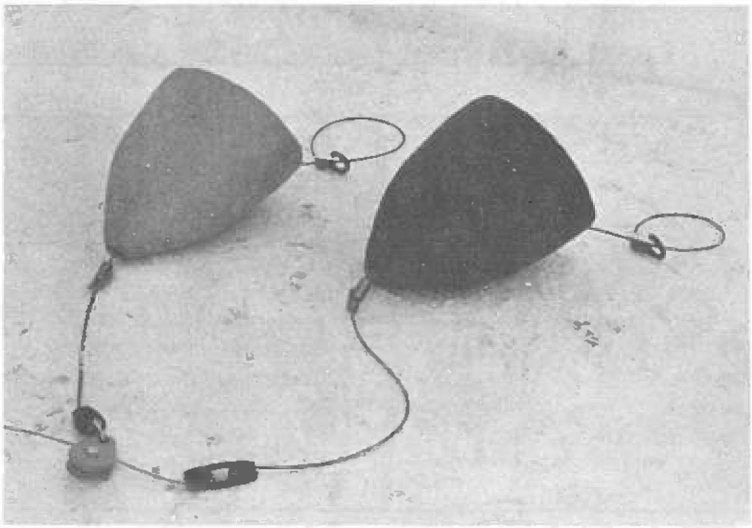
Independent Bunching Winches can be used to collect small logs in order to improve the efficiency and economy of transport to the roadside by other equipment such as tractors, skidders and forwarders in gentle terrain or skyline cranes in steep terrain. In other words, these winches can be used to shorten the lateral skidding or yarding distance on the main equipment and they are sometimes used as the main equipment to transport to the roadside, where the extracted trees or logs can be loaded on to trucks or trailers.

Figure 1 - Independent Bunching Winch,
Radio controlled

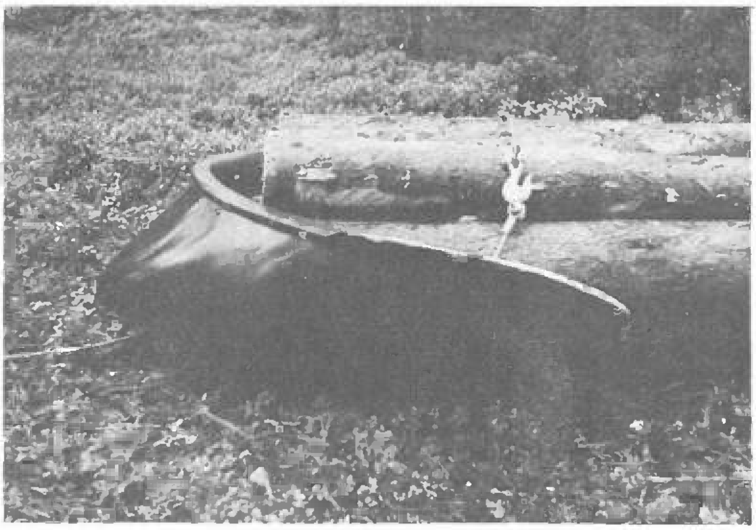
Photo: Courtesy Kolpe-Patent AB

Independent bunching winches usually have no haulback line so that the line must be pulled back to the logs manually. If the winch is radio-controlled, this system needs only one operator who pulls the line to the logs to be extracted, hooks up the logs, follows the logs into the bunching location, unhooks them and then pulls the line back for the next turn, while constantly retaining control of the winch with the radio (Figure 1). If the system is not radio-controlled it usually needs two men, i.e. a winch operator and a chokerman (choker setter-cum-line puller).

Figure 2 - Skidding Cones



Standard cone
Photo: Courtesy Kolpe-Patent AB



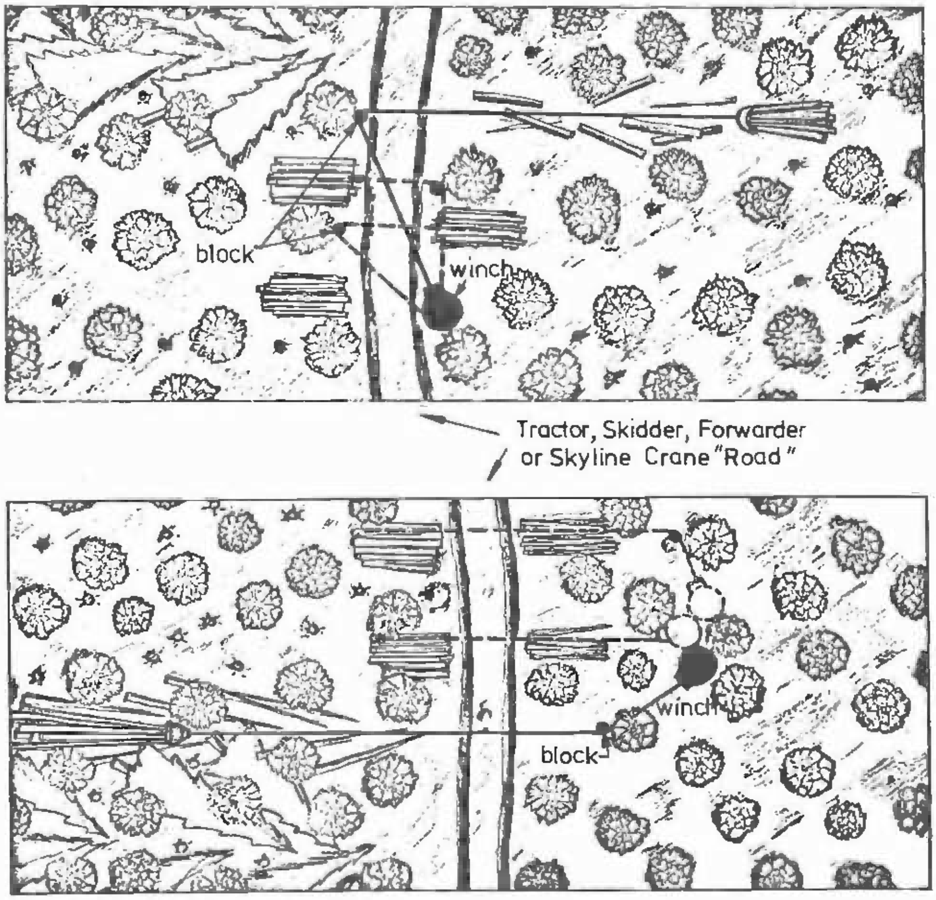
Pan shaped cone
Photo: Courtesy Kolpe-Patent AB

Since there is often no lift with this system it is necessary to minimize hang-ups through other means such as cutting low stumps and using skidding cones, pans or sledges (Figure 2).

The winch is moved by pulling itself along with its winching line. However, when changing from one yarding strip to an adjacent yarding strip, it is usually easier and faster to use blocks to relocate the lines and thus change the direction of pull, rather than to move the winch itself (Figure 3).

In the felling operation, the trees must be directed in a manner that will make the winching operation as efficient as possible. This normally requires felling the trees in the direction in which they will be winched.

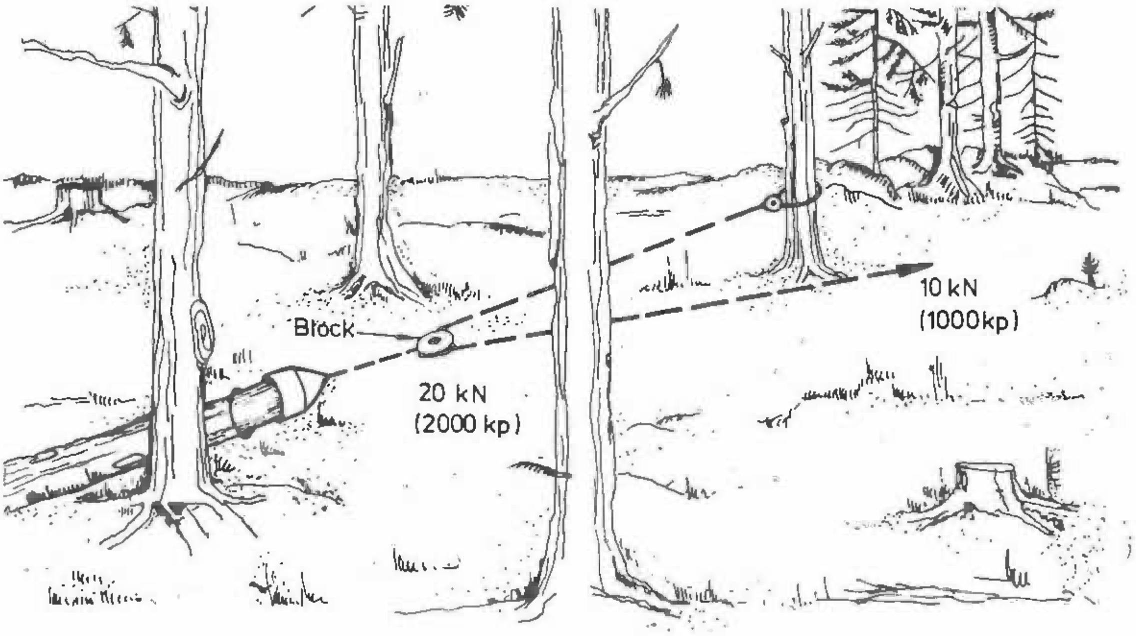
Figure 3 - Changing Yarding Strips with Blocks



Courtesy Nordfor Teknik AB

This equipment is designed for bunching small wood. It is ideally suited for use in a first thinning in small dimension wood. Should it be necessary to move an occasional larger log, the pulling power can be increased by using a block for mechanical advantage (Figure 4).

Figure 4 - Using a Block to Increase Pulling Power



Independent bunching winches can also be used for other purposes such as pulling the skidding line (mainline) out laterally from a skyline crane. A recent development, although the principle is old, is to use the winch for mechanically delimbing small trees by pulling them through a small limbing device.

The general specifications for independent bunching winches are given in Table 1. Some selected examples are given in Appendix 1.

Table 1 - Independent Bunching Winches - General Specifications

Maximum pulling power	5 to 45 kN (500 to 4 500 kp)
Maximum line speed	0.4 to 1.5 m/s
Maximum drum capacity	50 to 250 m
Engine power	4 to 37 kW (5 to 50 hp)
Weight	40 to 750 kg

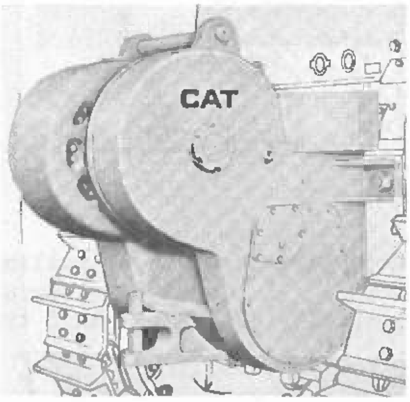
2.2 Machine-mounted Winches

Machine-mounted winches (Figure 5) on tractors, skidders, forwarders etc., are used to collect the logs which are then transported by the machine to the roadside. In many regions this is the most common means of collecting and transporting wood. Such winches are advantageous in broken terrain in which a machine with only a grapple or crane cannot reach all the logs without wasting time in getting to the logs and disturbing the soil unnecessarily.

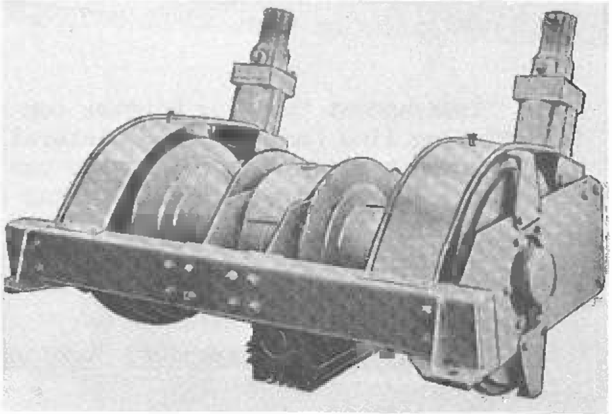
These winches vary in number of drums and whether they are mounted with or without towers. There are also considerable differences in the capacities of the various winches. This is primarily due to differences in the size and weight of the logs to be moved, the winching distances required and the size and weight of the base machines for which the equipment is designed.

The task performed with these winches is called "winching". In winching, the cable and chokers are pulled out manually from the machine and fastened to the logs. The logs are then winched to the machine and transported to the roadside. Pre-set chokers can be used to advantage in many situations. The winch is most often manually controlled although radio-controlled units are used in some regions. Bunching usually requires two men; one chokerman and one machine operator. However, it is not unusual for the machine operator to also set chokers.

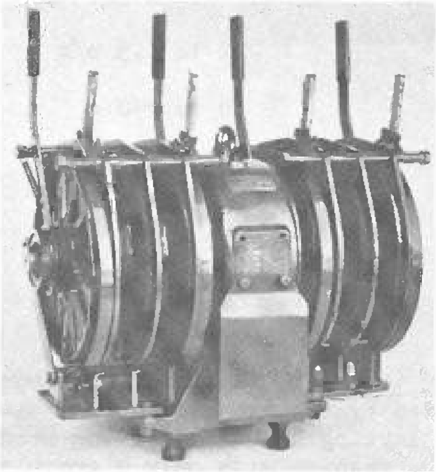
Figure 5 - Machine-mounted Winches



Single drum winch
Courtesy Caterpillar



Double drum winch
Courtesy Sepson

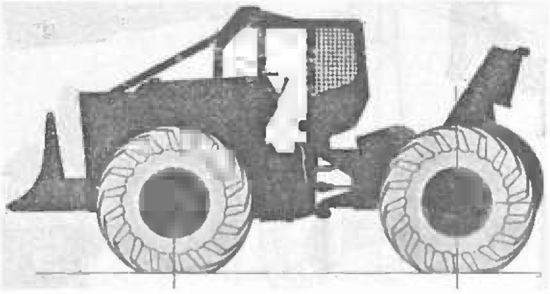


Four drum winch
Courtesy Per Iglands Fabrik A/S

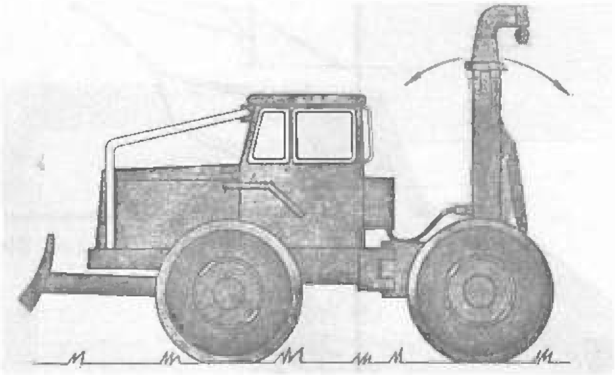
Some variations are shown in Figure 6. When a winch is equipped with two or more drums, it can be used in various cable configurations such as those described under Yarders. When it is also equipped with a tower, it can be used in various ways, as shown in Figure 7. The configurations shown in Figures 7b, 7c and 7d are described under Yarders, Mobile Tower Yarders and Running Skyline Swing Yarders. An interlocked double drum winch which operates on the interlock principles described under Running Skyline Swing Yarders has recently been developed in Norway. These examples illustrate the great flexibility of winching and cable logging systems.

In the felling operation, the trees must be directed in a manner that will make the winching operation as efficient as possible. This normally requires felling the trees toward or away from the direction in which they will be winched.

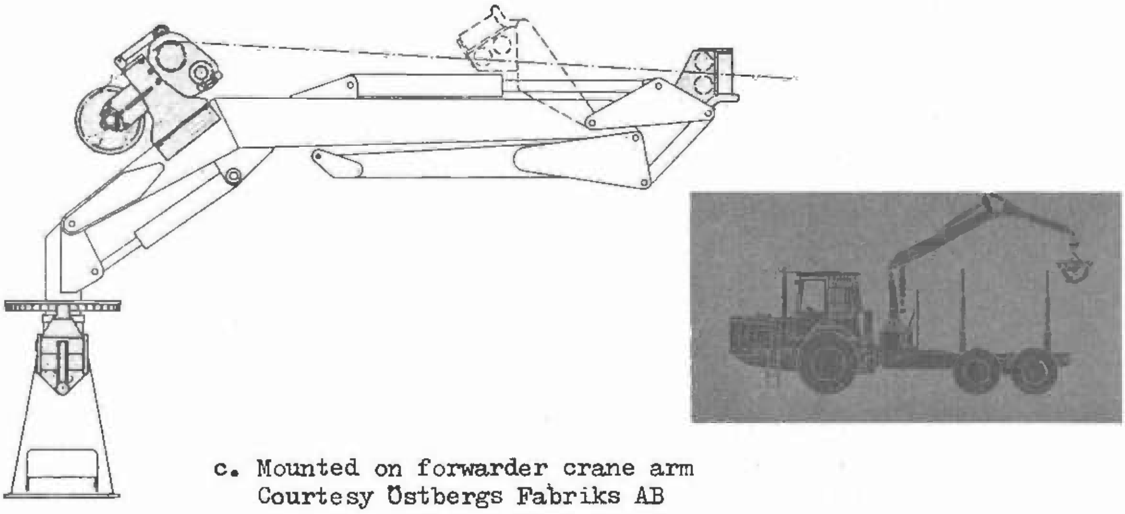
Figure 6 - Variations Using a Single Drum Winch



a. Mounted on skidder with arch
Courtesy Eaton Yale Ltd

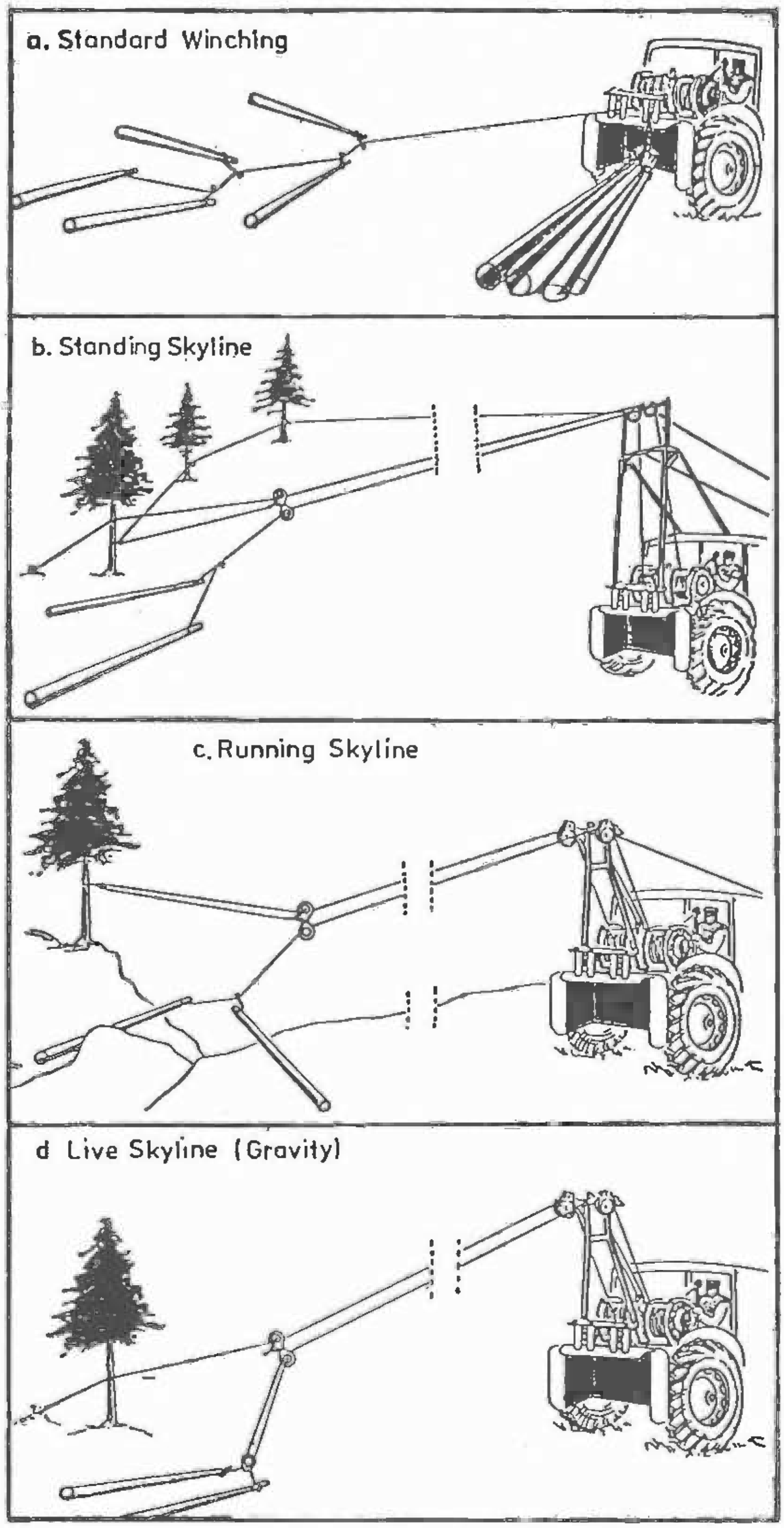


b. Mounted on skidder with tiltable crane post (with or without haulback drum)
Courtesy Nordfor Teknik AB



c. Mounted on forwarder crane arm
Courtesy Östbergs Fabriks AB

Figure 7 - Some Variations using a Double-Drum Winch



Courtesy: Per Iglands Fabrik A/S

The general specifications for machine-mounted winches are given in Appendix 1.

Table 2 - Machine-mounted Winches for Ground Machines - General Specifications

Number of drums	1 to 4
Maximum pulling power	10 to 735 kN (1 000 to 75 000 kp)
Maximum line speed	0.4 to 2.5 m/s
Maximum drum capacity	30 to 800 m
"Tower" height	0 to 5.5 m
Engine power of base machine	11 to 336 kW (15 to 450 hp)
Weight of winch	100 to 2 000 kg

2.3 Yarders

Yarders are the most commonly used cable logging machines. The equipment is used in a manner similar to the mobile tower yarders, discussed in Section 2.5. A major difference is that the yarding distance for this equipment can be greater[1] than for the small mobile tower yarders used in Europe (Section 2.5.1).

Yarders can be transferred by trucks, trailers or tractors. Central European yarders are mounted on sleds, as are the high-lead yarders (donkeys) still used in Asia, and these can move over the terrain under their own power. Some yarders are operated without being unloaded from trucks, trailers or tractors and are used in a manner similar to the mobile yarders. In extremely difficult terrain they are sometimes transferred in pieces.

The yarder generally consists of 1 to 3 single drums, which are sometimes grooved (Figure 8), or endless pulleys, with an engine as a source of power. The number and type of drums in a yarder should be selected carefully because these limit the variation of the cable configurations which can be used. A set of grooved drums or an endless pulley are used to power the circulating line in the so-called "continuous line" or "endless line" system.

Instead of using a prebuilt tower these systems use elevated blocks and intermediate supports suspended from trees and poles to obtain the desired height and thus keep the load from dragging on the ground. Examples of such supports are shown in Figure 9 and Figures 16 to 22.

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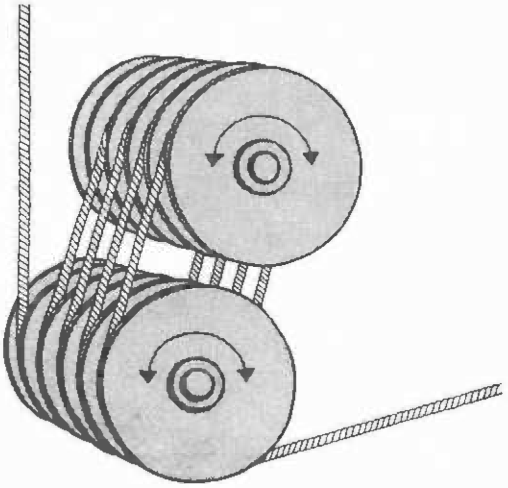
[1] Because the drum capacity of yarders is generally greater and because of the greater stability of a sled-mounted yarder and its guying system.

Figure 8 - Example of Grooved Drums



Courtesy Kolpe-Patent AB

In general, it can be said that yarders are used in skyline systems mainly in Europe and Japan, and the highlead system which is still in use in its original form, especially in Southeast Asia, as shown in Figure 16. The highlead system is also still in use in North America, but generally with mobile towers which are covered in Section 2.5.

The skyline systems with or without intermediate supports are classified as follows:

- Single-span Skyline System
- Multi-span Skyline System

These two systems have no fundamental mechanical difference. A multi-span skyline system is considered to be a series of single-span skyline systems.

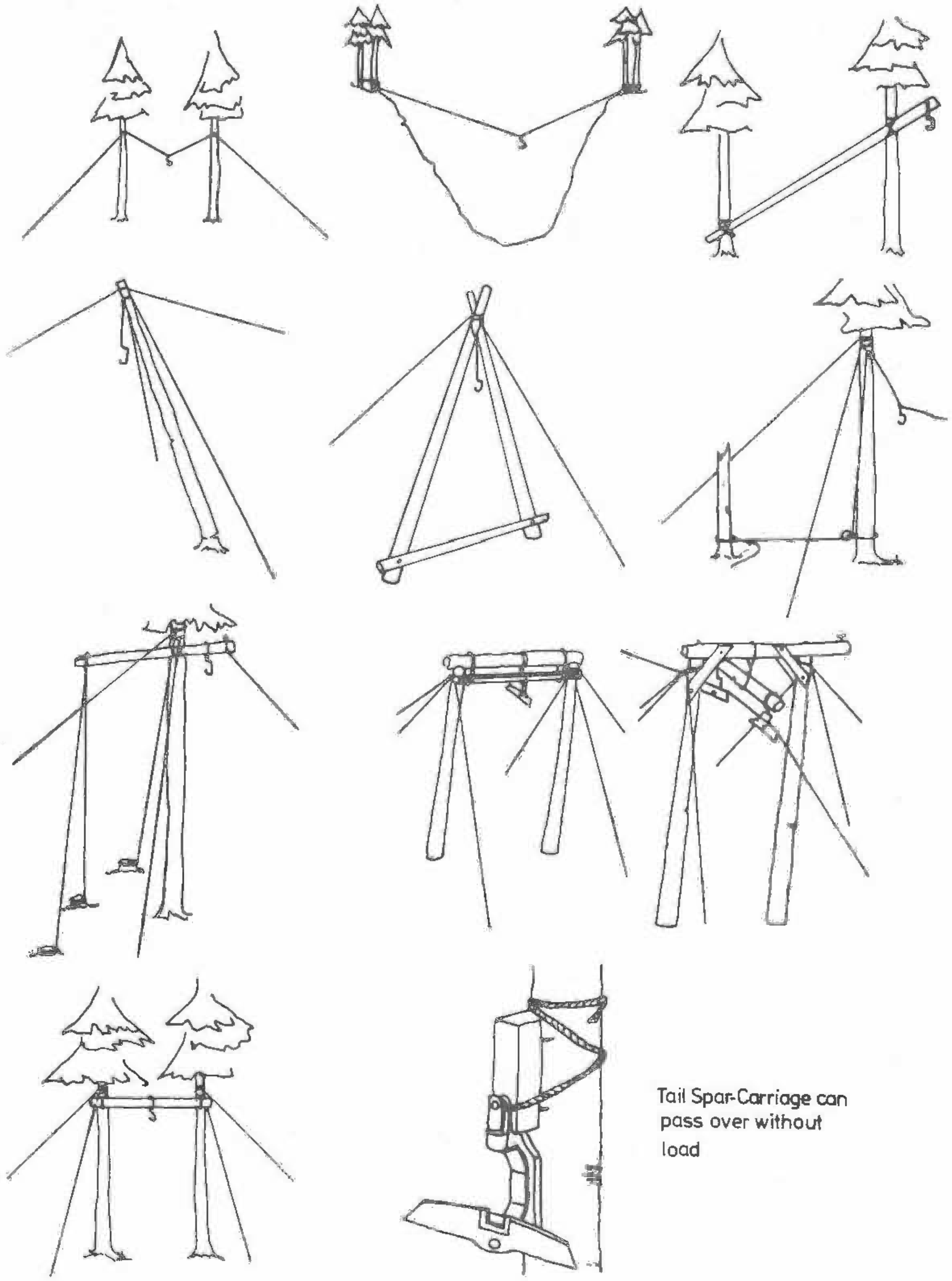
Intermediate supports are time-consuming and often expensive to rig up and to build. Construction of intermediate supports is normally done with a three-man crew and requires about half a day or more per support, depending upon its complexity. The multi-span skyline system is generally used for long transportation where no other methods are suitable.

When intermediate supports are not enough to obtain the desired height or lift to keep the load from dragging on the ground because of uneven terrain, a set of two or more yarders is sometimes used, some for yarding and some for swinging, instead of the multi-span skyline system. However, this use of more than one yarder is more time-consuming not only in moving, setting-up and taking down, but also in the logging operation itself.

In Japan, the multi-span skyline system, or the systems with a set of two or more yarders, were once employed because of the steep and undulating terrain and the low density of roads. With the development of more roads into forest areas, however, these systems are seldom used now.

In the general operation of these systems, a crew consists of a minimum of three men: one machine operator, at least one chokerman and at least one landing man (chaser). Communication between the crew is usually performed by hand or flag signals in short (visible) distances or by radio transmitter, or electric whistles over longer distances.

Figure 9 - Examples of Intermediate Skyline Supports



Tail Spar-Carriage can pass over without load

Courtesy: Koller Seilbahnen

In the felling operation the trees must be directed in a manner that will make the yarding as efficient as possible. This is especially important in thinnings and partial cuts. Independent bunching winches are sometimes used for pre-bunching the wood in thinnings. In clearcuts the felling direction is not as critical as in thinnings and partial cuts, but felling if at all possible should be to lead. Stumps should be as low as possible to minimize hang-ups.

The planning and layout of skylines is based upon the principles of skyline tension and deflection design. Long spans of over 1 000 metres in length are used in the European Alps when the deflection is good. In multi-span skyline systems, yarding distances of over 4 000 metres are possible and the layout is calculated for each span using the principles of skyline tension and deflection. These systems often employ skyline cranes, i.e. carriages that can yard laterally to the skyline. Examples of these carriages are shown in Figures 39, 40, 41 and 42.

The number and type of drums on yarders enable or limit the type of yarding operation which may be carried out, for instance the interaction between a mainline and a haulback allow for the use of a North Bend system (Figure 20), whereas a single drum winch would not.

The major cable configurations are also given in the section on large mobile tower yarders. Cable configurations can be placed in two main categories:

- Gravity Systems

- All-terrain Systems

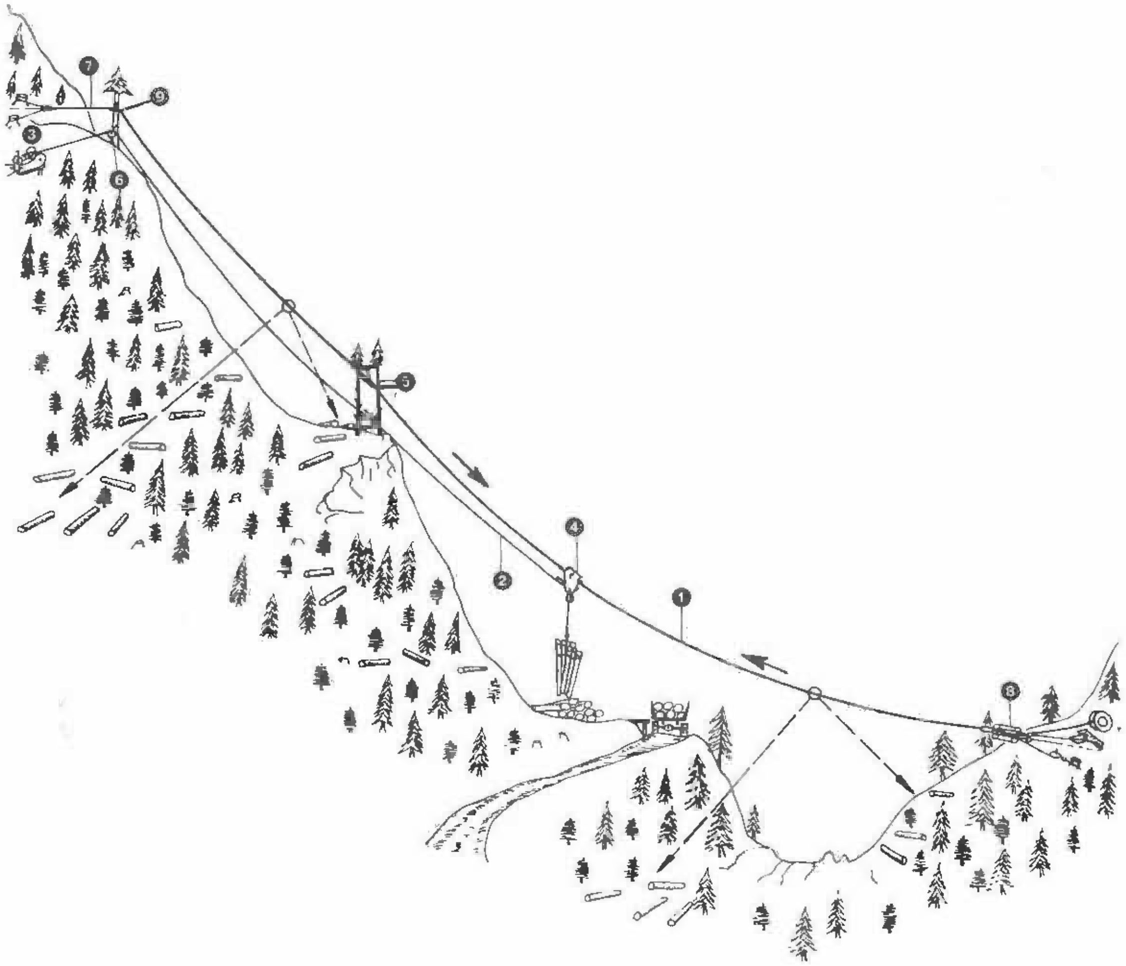
Gravity systems are the "traditional" systems of Central Europe. These systems normally require the placement of the yarder (Figure 13) at the upper end (Figure 10) of the logging area. If there is no road close by, it can take considerable time to move the yarder to the back of the logging unit. The operator must walk out to the machine each day or camp there and it can be difficult and time-consuming to get parts, equipment and personnel to the yarder for repair and maintenance work.

In the traditional use of gravity systems the load was lowered downhill and braked by the yarder since the roads were located in the valley bottoms. There was no need for the powerful yarders required for uphill yarding. Over the years there has been an increasing need for uphill yarding. This has resulted in the development of more powerful yarders with faster line speeds.

It is necessary for the slope of the skyline to be such that gravity will carry the carriage to where it is needed, as shown in Figure 10.

All-terrain systems in Central Europe are basically a modification of the gravity systems in which the operating cable is endless or is attached to either end of the skyline crane and functions as a mainline and haulback line. Because of this the system is independent of gravity and can be used for flat or adverse terrain as well as favourable (downhill with the load) terrain. The yarder can be located anywhere along the skyline. This is an advantage as the yarder can be located near the road where it is easily accessible for maintenance and repair, for fueling and for the operator. In addition, it does not require the long and sometimes dangerous operation of winching the yarder to the back end of the operating area (Figures 11 and 12).

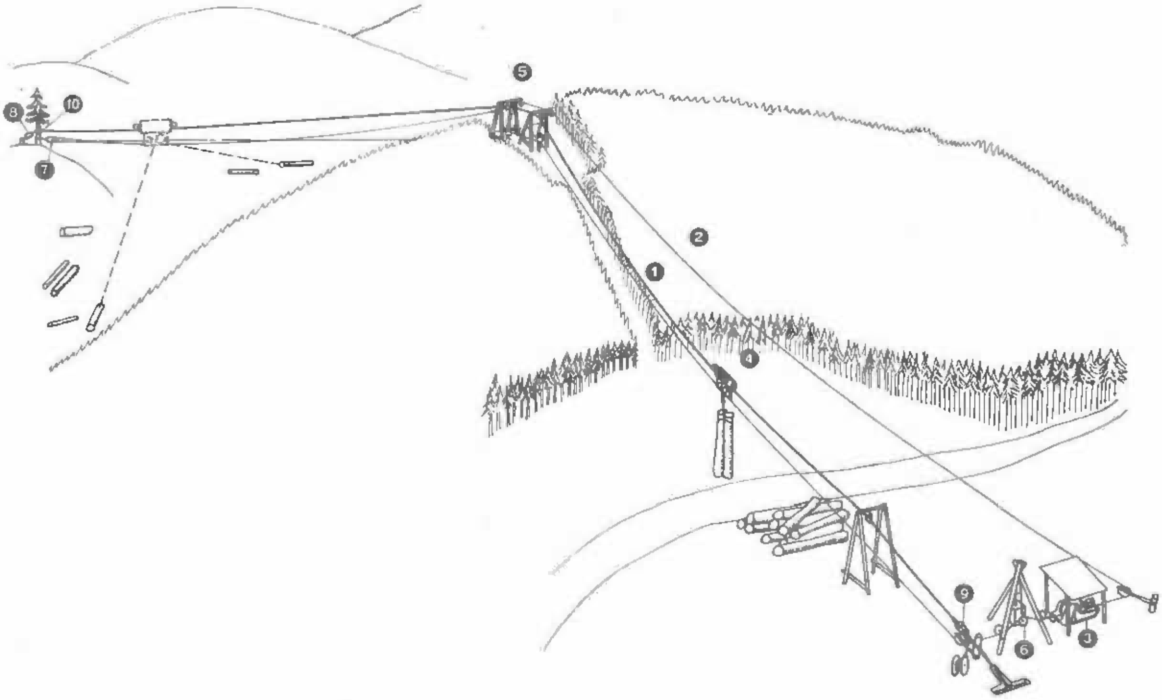
Figure 10 - Gravity Multispan Skyline System - Central Europe



① Skyline
② Hauling and lifting line
③ Drive winch
④ Gravity Carriage
⑤ Intermediate support
⑥ Hauling line block
⑦ Skyline anchoring
⑧ Skyline tensioning device
⑨ Skyline end block

Courtesy: Reinhold Hinteregger

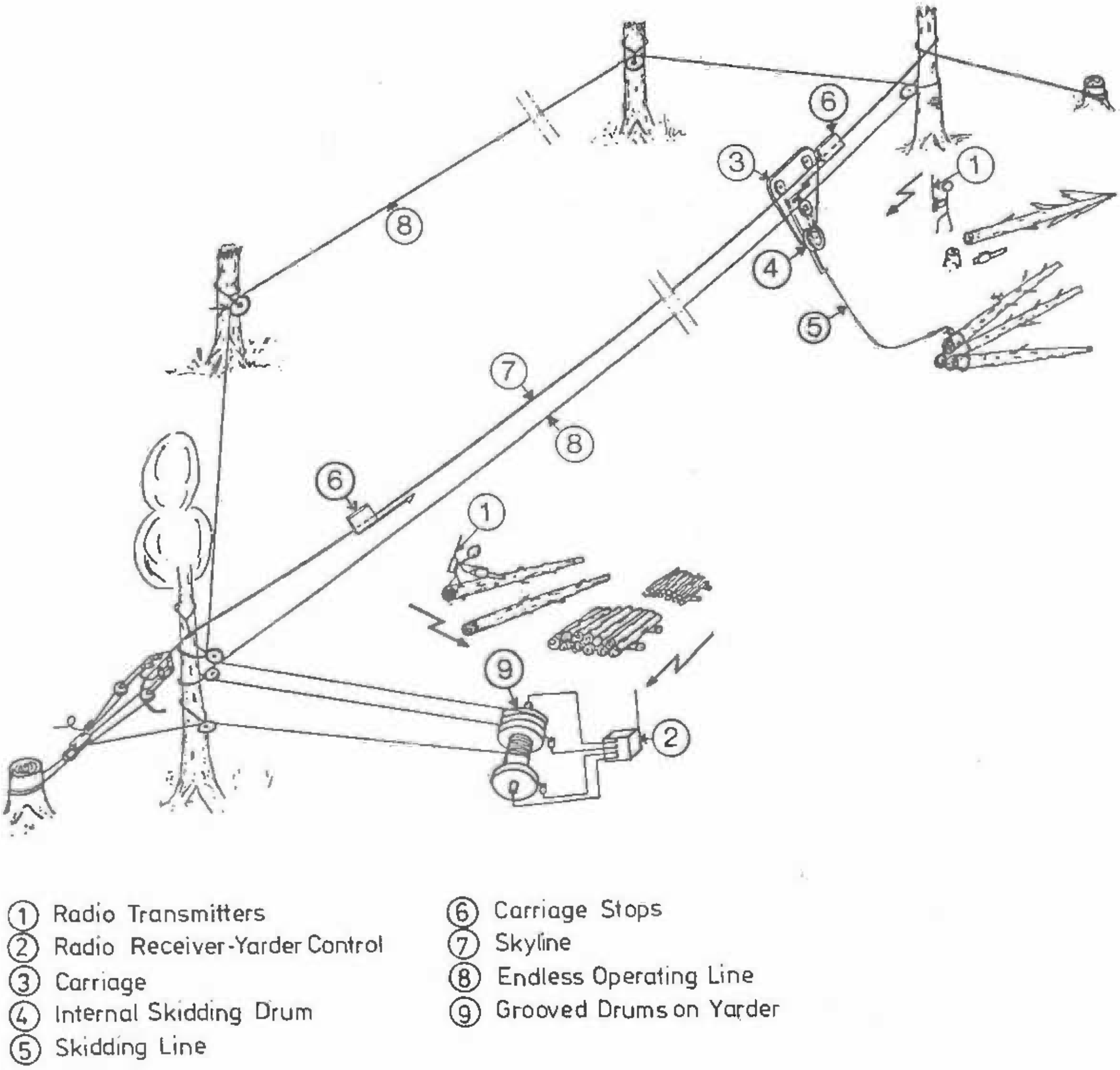
Figure 11 - All-Terrain Multispan Skyline System - Central Europe



① Skyline
② Circulating line
③ Drive winch
④ All-terrain Carriage
⑤ Intermediate support
⑥ Circulating line - tension tower
with tension weight
⑦ Circulating line - tail block
⑧ Skyline anchoring
⑨ Skyline tensioning device
⑩ Skyline end block

Courtesy: Norwegian Forest Research Institute

Figure 12 - All-Terrain Multispan Skyline System - Radio-controlled, Norway

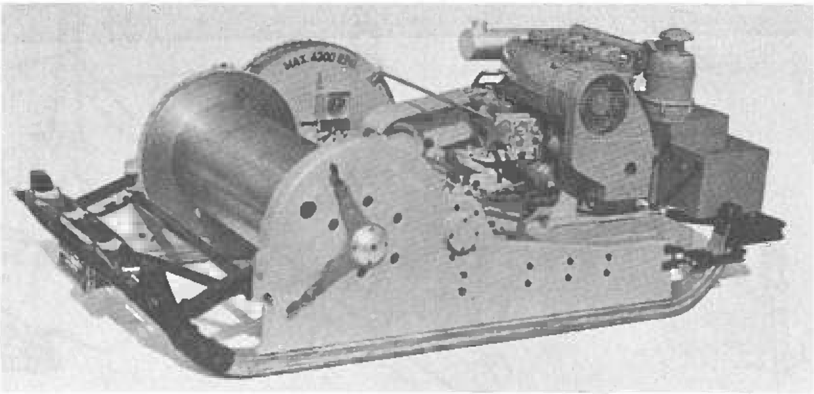


Courtesy: Norwegian Forest Research Institute

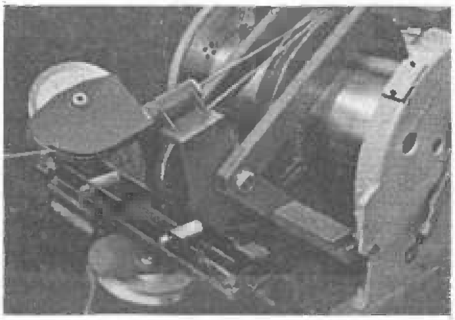
Due to the endless line (continuous line) feature, in which the line is driven by a set of grooved drums or an endless pulley, drum capacity does not determine the yarding distance. Since the grooved drums can be mounted onto an existing Central European gravity yarder, there is no need to acquire a special yarder for an all-terrain system (Figure 13).

In Japan, the gravity systems were first imported from Europe. However, there has been increasing need for uphill yarding in complex terrain. Many cable configurations have been developed based upon the European ones. Two- or three-drum yarders are so designed as to be able to rig them with endless pulleys.

Figure 13 - Central European Multispan Skyline System Yarders



a. Gravity yarder (single drum)



b. All-terrain yarder (gravity yarder with grooved drums)

Courtesy: Wyssen Skyline-Cranes

A Norwegian yarder is equipped with grooved drums as original equipment (Figure 14) and is not a modified gravity yarder.

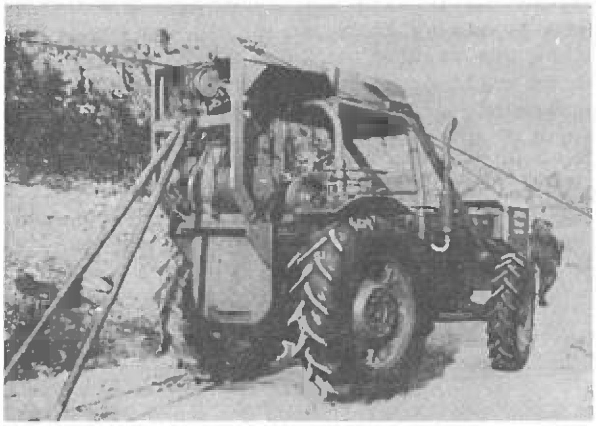
There are radio-controlled systems with radio-controlled carriages, or radio-controlled yarders. A self-release hook is also used to lower the number of crew required.

The general specifications for yarders are given in Table 3. Some selected examples are given in Appendix 1.

Table 3 - Yarders - General Specifications

Maximum load capacity	900 to 12 000 kg
Maximum pulling power	10 to 150 kN (1000 to 15 000 kp)
Maximum line speed	2.0 to 10.0 m/s
Maximum drum capacity	600 to 4 200 m
Engine power	7 to 149 kW (10 to 200 hp)
Weight of yarder	500 to 7 000 kg

Figure 14 - Yarder with Grooved Drums for All-Terrain Application, Radio-controlled - Norway



Tractor mounted

Truck mounted

Courtesy: Norwegian Forest Research Institute

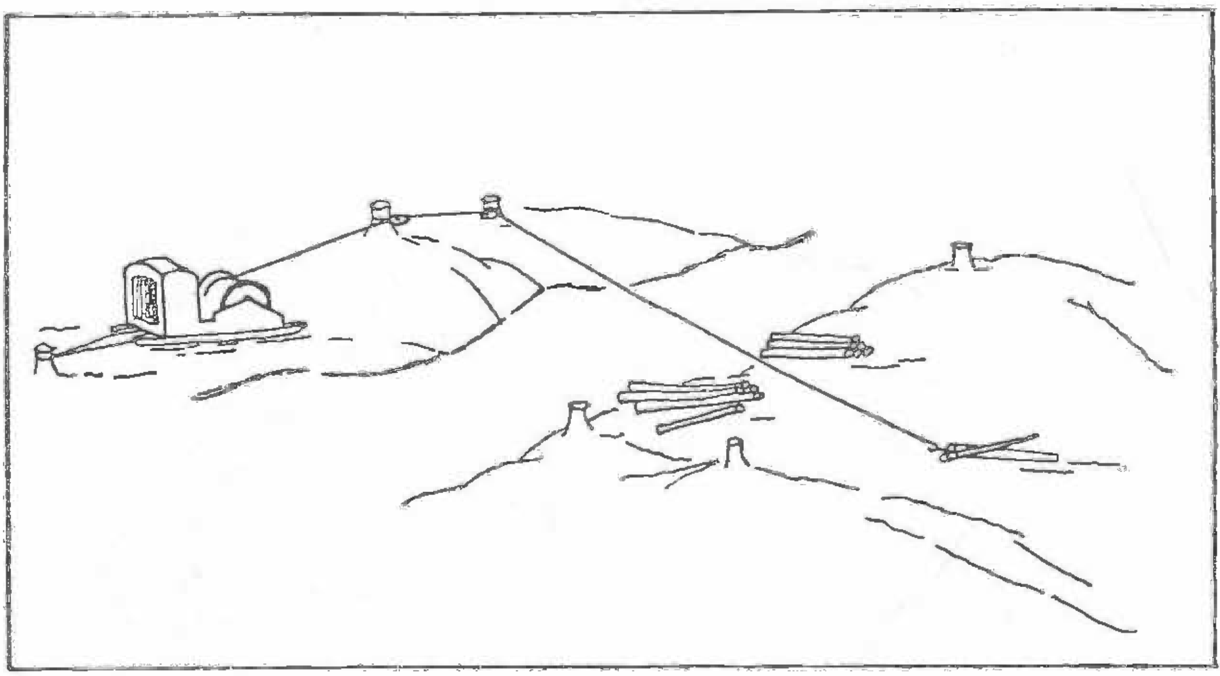
Major cable systems are described below:

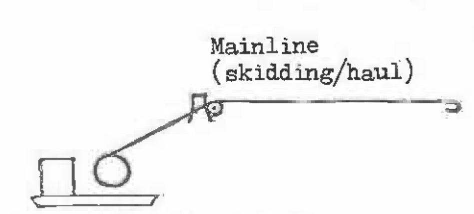
2.3.1 Ground Lead (Figure 15)

This system is the simplest of all cable configurations. Originally it consisted of a power supply and an operating line. The power supply could be a gasoline or diesel engine while, in the more primitive form, an animal was used. Independent bunching winches or machine-mounted winches can be used instead of yarders, as described in the respective sections. This system is still popular and normally used on terrain too steep for the safe operation of surface equipment. In the original form, power is supplied only for the hauling; therefore, since there is no haulback drum, the mainline must be hauled out by manual means.

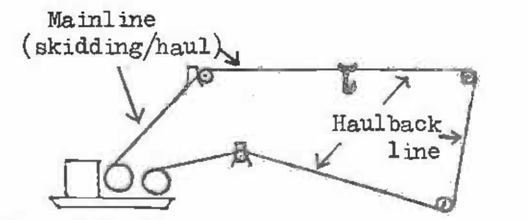
The major advantages are low initial cost and maintenance, simplicity and short set-up and take-down times. Main disadvantages are limited yarding distance, very low volume per turn and a great amount of soil disturbance.

Figure 15 - Ground Lead (System)





Ground Lead (original)
With single operating drum



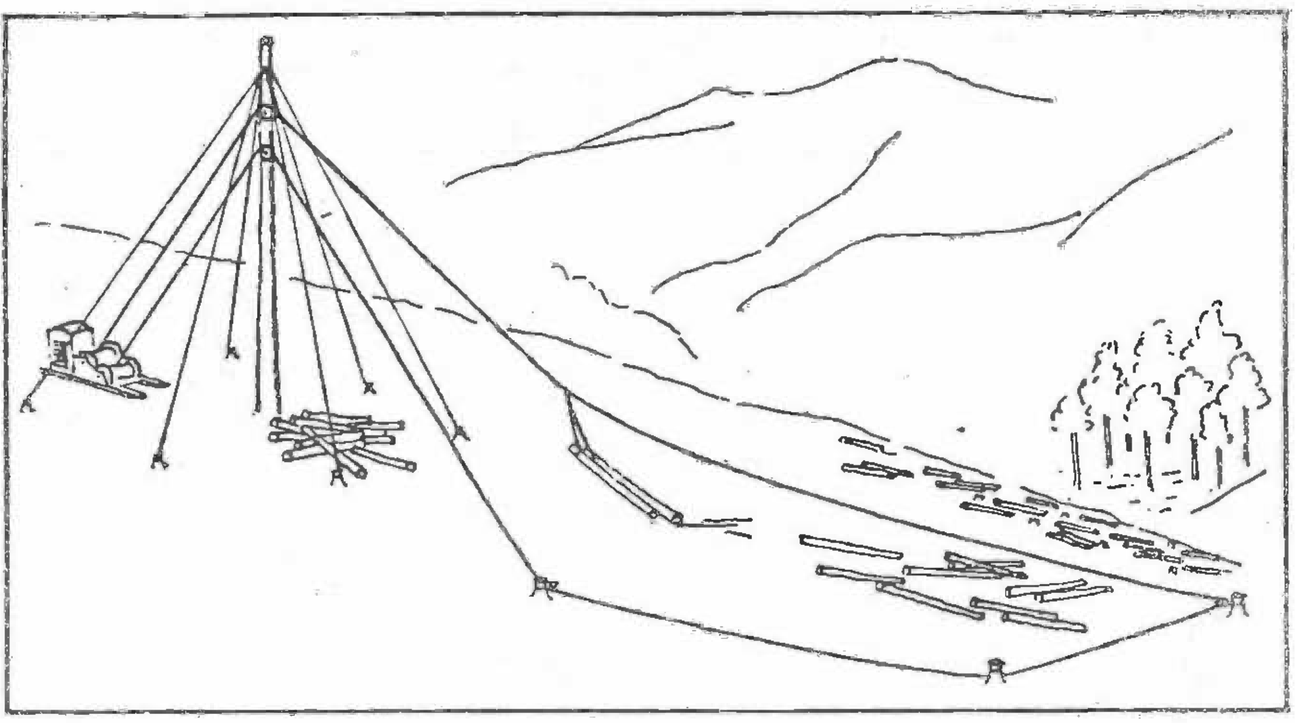
Ground Lead
With haulback line & 2 operating drums

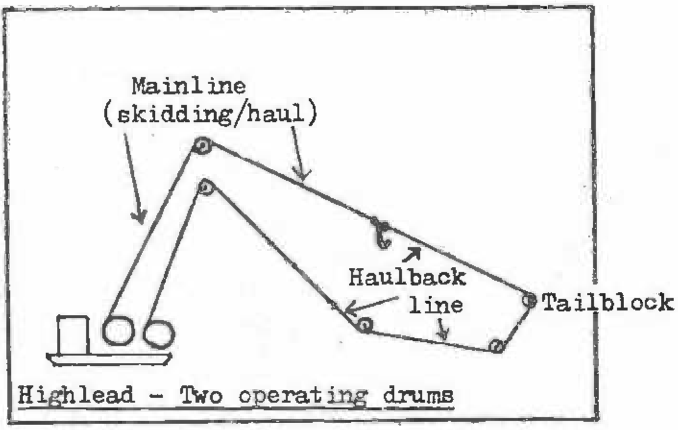
2.3.2 High Lead (Figure 16)

This system originated from the ground lead system. The difference is only an elevated block which is installed on the head spar. It is normally used on a clearcut operation to yard uphill and downhill for relatively short distances. Because the haulback line runs through a tailblock attached to a stump, the system does not provide much vertical lift on the logs. The logs, therefore, are dragged on the ground with a vertical lift only at the front end near the spar. While under certain soil and topographic conditions this system can cause extensive soil damage, it is popular for its simplicity and low capital investment.

An important modification to the yarder is an interlock mechanism which ties the main and haulback drums, allowing the lines to work in unison, thus creating a tightline effect, providing additional lift. Thus an interlock will help to overcome drag and hang-ups and lessen damage to the soil.

Figure 16 - Highlead (System)





Highlead - Two operating drums

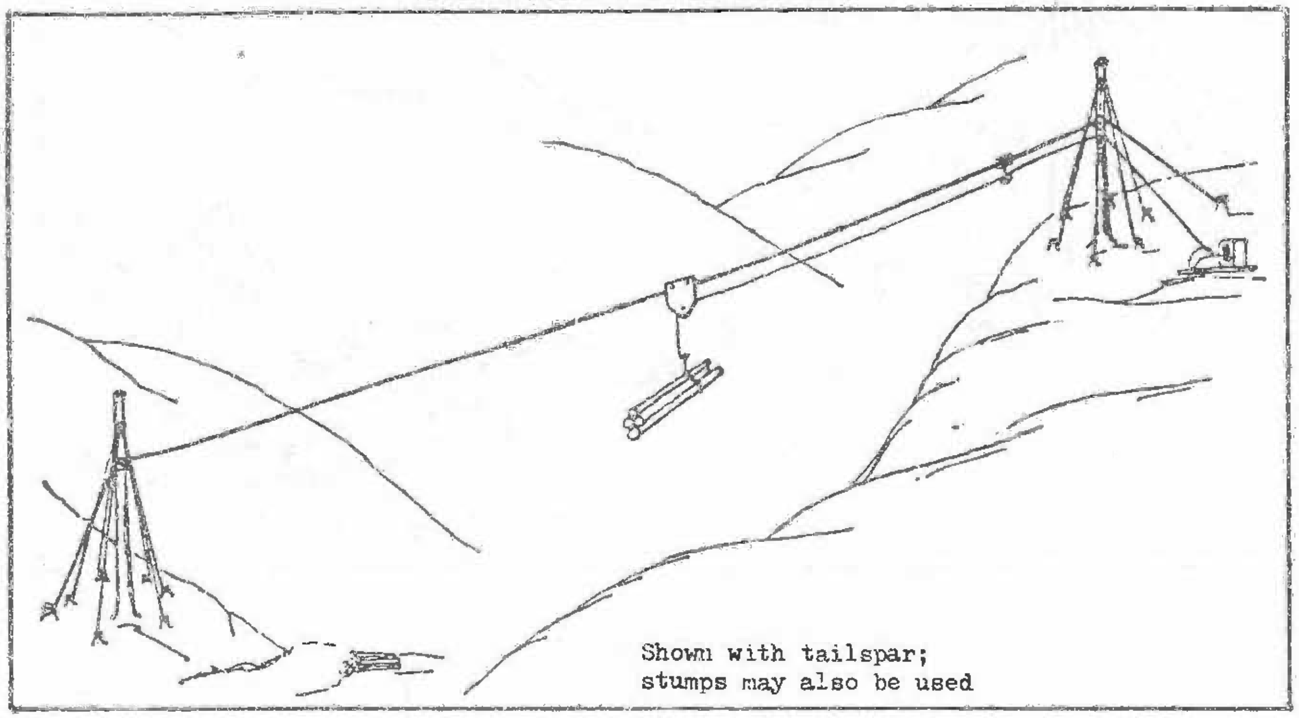
2.3.3 Snubbing (Figure 17)

This is a typical gravity system. While it can be used in clearcut, partial cut and thinnings, it is usually used for downhill swinging over long distances. The yarder is placed at the upper end and a special gravity carriage is used. The single-operating drum yarder pulls the empty carriage up along the skyline to the logs, and when the carriage is stopped it is locked to the skyline and the snubline is lowered down to the logs. When the logs are lifted, the carriage lock disengages and then the carriage is lowered along to the landing site by gravity, with the carriage and logs kept under control by snubbing.

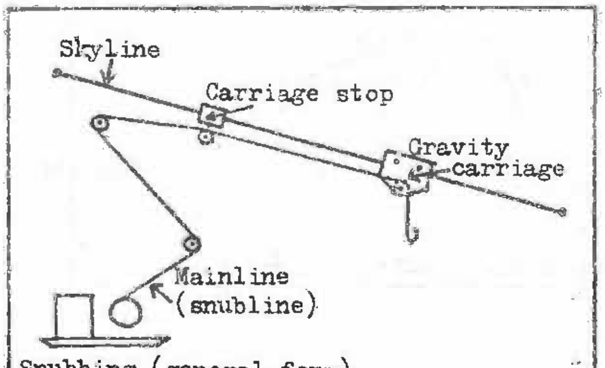
Intermediate supports are frequently used for this system (see Figure 10). Numerous gravity carriages have been developed and are sold under various names - some are relatively simple while others are quite complicated. A radio-controlled carriage is also used in some regions.

The major disadvantages are: relatively low daily production, long set-up and take-down times, especially the movement of the yarder to its operating position and thus the problems with maintenance. In general, it has a limited lateral yarding distance which must be done manually or by use of other equipment. However, it has the advantage that only a one-drum yarder is needed and that it can be used for long swings when the road density is low.

Figure 17 - Snubbing (System)



Shown with tailspar;
stumps may also be used



Snubbing (general form)
Single operating drum, gravity carriage

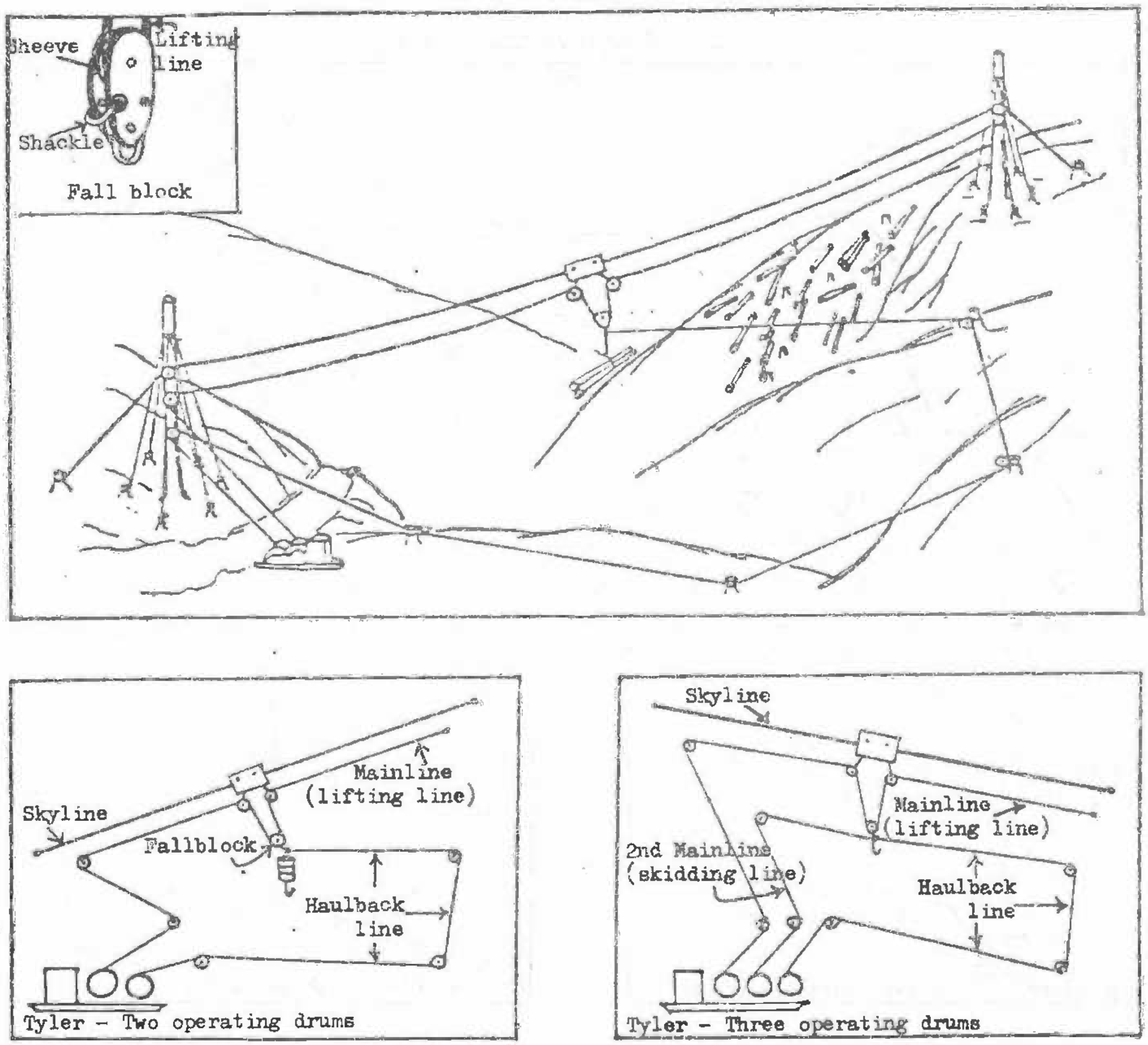
2.3.4 Tyler System (Figure 18)

An uphill and downhill system which uses a standing or tight skyline to provide lift on the logs with the help of a lifting line. The system is often used to swing logs across canyons and out of tight situations.

The number of drums required on the yarder depends on whether the swing is uphill or downhill. In Japan, the Tyler system has replaced the old snubbing system mainly because the yarder (two-drum) can be positioned at the roadside. For uphill swinging a third drum handles a second mainline or skidding line which is used to pull the turn up the landing. This line may also be required in other situations.

The ordinary carriage is pulled along the skyline to the log pile or logs by the haulback, the fall block with chokers is lowered to the logs by slacking off on the lifting line and once the logs are choked they are lifted by tightening the lifting line. The carriage with logs is either lowered or pulled to the landing, depending on the uphill/downhill nature of the setting. The haulback may be used for lateral yarding if required. However, this system is less suitable for long swings in Japan because of the limited line holding capacity of the haulback drums in use.

Figure 18 - Tyler (System)



2.3.5 Endless System (Figure 11)

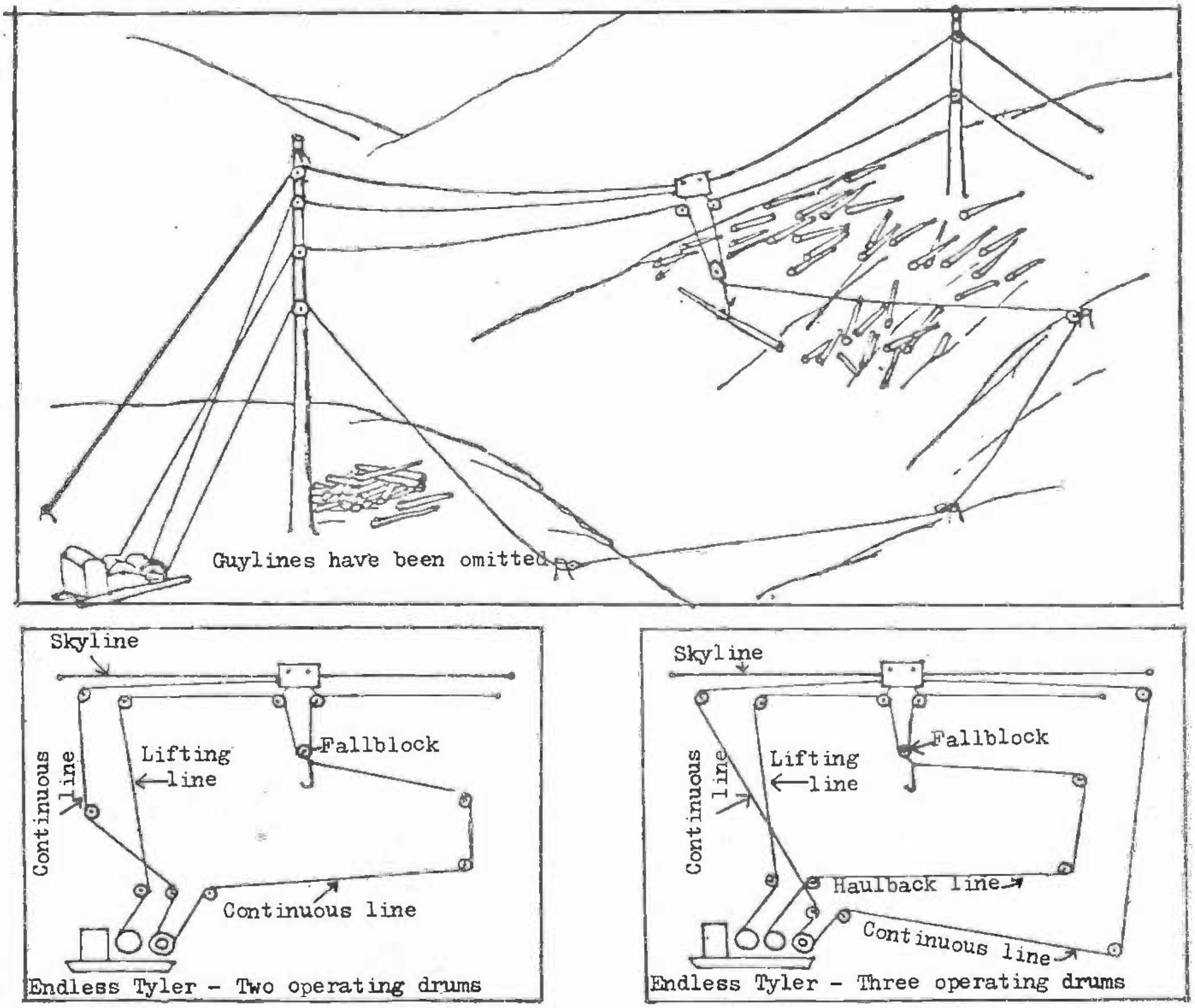
This is one of the all-terrain systems and is generally used for long distance transportation. It employs a continuous line (endless line) operated from a yarder with a grooved drum (or endless pulley). The carriage is moved by the continuous line and the skidding line is lowered or raised by an internal drum fitted inside the carriage (see Figures 39 and 40). For lateral yarding the skidding line must be pulled out manually.

2.3.6 Endless Tyler (Figure 19)

This system is based on the Tyler system. In Japan it is the most common system used in clearcut operations and many versions have been devised. The system employs a continuous line instead of the 2nd mainline and the haulback line as in the Tyler. The so-called continuous line is not endless, but is interconnected through the fallblock and carriage. In general, the continuous line moves the carriage along the skyline and the fallblock moves laterally to the logs. The fallblock is controlled by tensioning and slackening of the lifting line.

This system has advantages and disadvantages similar to those of the Tyler. However, it has a big advantage in that it is suitable for all types of terrain. This system needs great engineering and planning skills and a lot of set-up and take-down time is required.

Figure 19 - Endless Tyler (System)



Endless Tyler - Two operating drums

Endless Tyler - Three operating drums

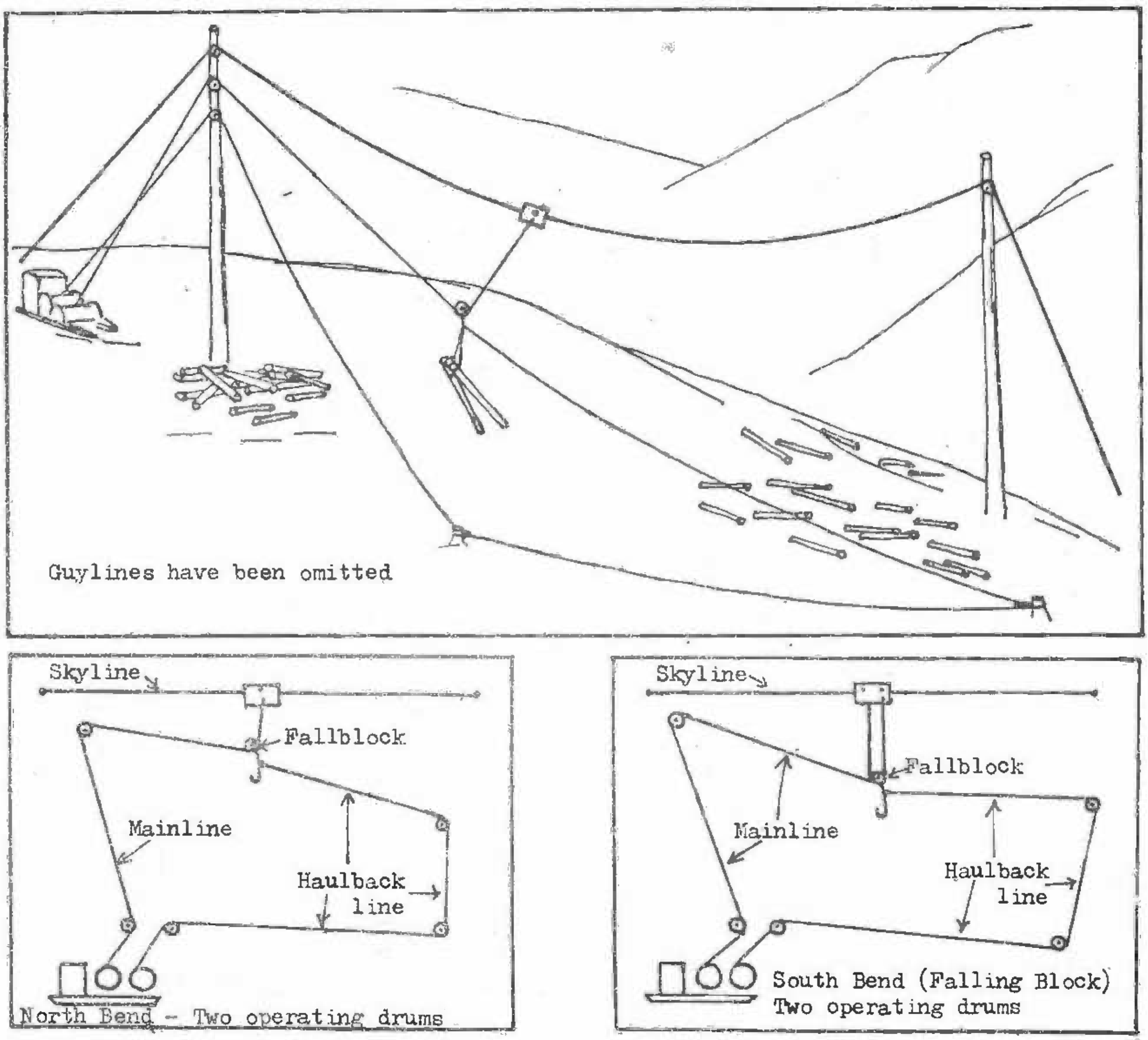
2.3.7 North Bend (Figure 20)

This is one of the most commonly used standing skyline systems. It is useful for logging uphill, level or moderate downhill slopes. The yarding distance can be up to 500 m when deflection is suitable.

The carriage and the fallblock are controlled by the main and haulback lines. At least one end of the logs is dragged along the ground but when obstacles are encountered the fallblock can be raised by braking the haulback drum, (tightening), thereby lifting the turn upward until the obstacle is cleared. It is more advantageous than Highlead, since it can avoid hang-ups more easily and thus reach further; however it requires a tailspar. Its advantages over other skyline systems are that the same two-drum yarder can be used for Highlead, and that it has the simplest rigging of any standing skyline system.

There is a modified North Bend system called "South Bend" or "Falling Block" system. It differs from the conventional North Bend in that the mainline doubles back between the carriage and the fallblock. This gives a greater lift on the turn of logs than in the conventional North Bend system and thus better control. It is used for yarding uphill or downhill on steep slopes where the regular North Bend system would not provide sufficient lift to free the turn from obstacles, and since ground friction can be lowered and obstacles avoided, better production can be obtained.

Figure 20 - North Bend (System)



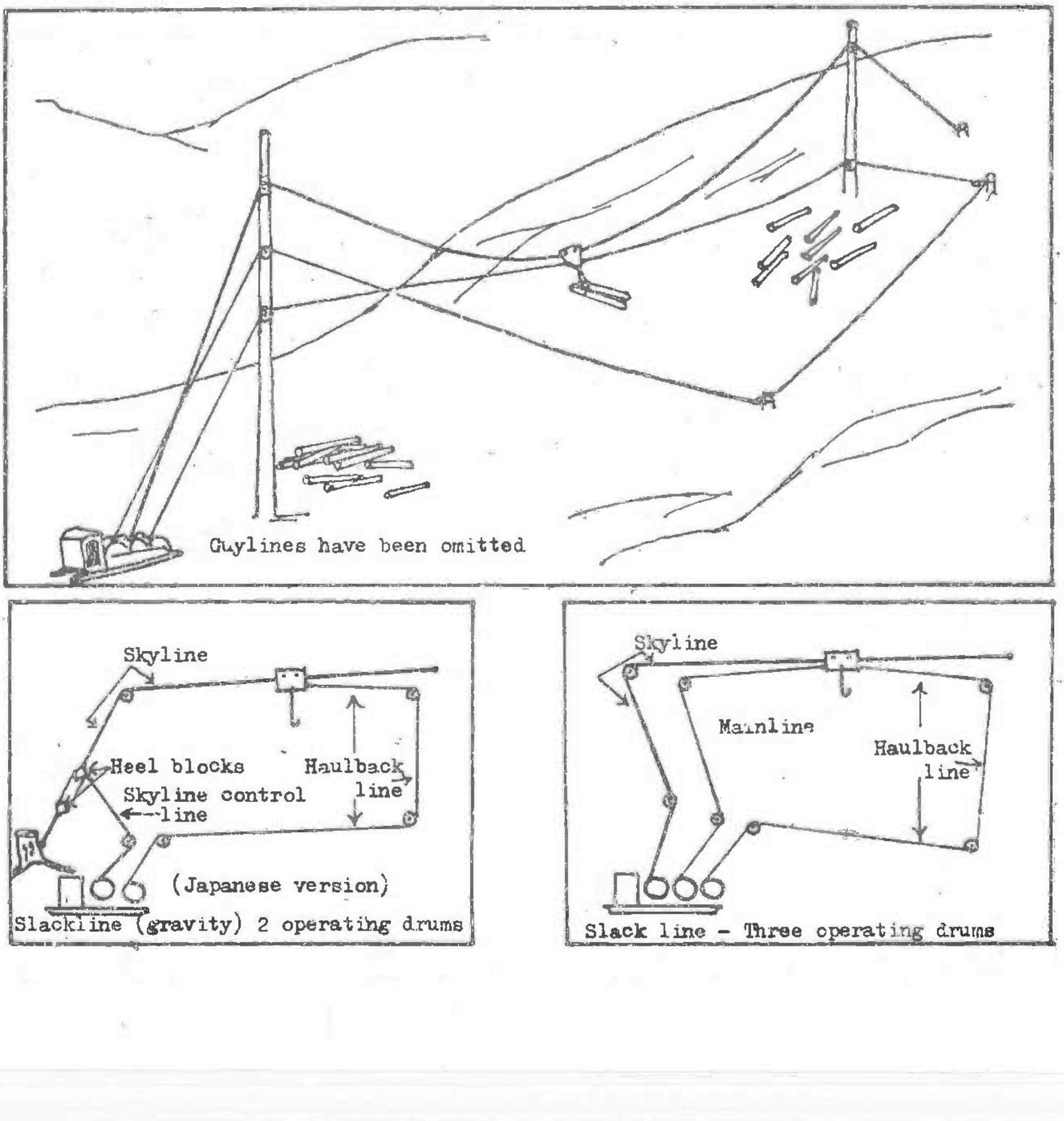
2.3.8 Slackline System (Figure 21)

This system is generally considered to be the best skyline system for yarding and is widely used for this purpose where the slope is downhill. It is also useful for swinging from piles and for moving logs across canyons and major obstacles.

This system, also sometimes referred to as a live skyline system, differs essentially from other skyline systems in that one end of the skyline is wound on a large drum on the yarder and is lowered to hook up logs, and then raised by winding on the skyline drum to lift the logs above the obstacles. The far end of the skyline is anchored to a stump(s) as in other skyline systems.

An additional drum is therefore required on the yarder to hold the skyline, and a large and expensive braking system is needed for the skyline drum. Advantages of the Slackline are: greater control of the log since it can be instantly elevated or lowered to accommodate ground conditions by tightening or slackening the skyline; the logs can be raised clear of the ground to minimize surface damage; and a skyline "road" can be changed more quickly than in the standing skyline systems since the skyline is reeled in with the skyline drum.

Figure 21 - Slackline (System)



The left-hand inset drawing in Figure 21 shows the Japanese method of controlling the skyline using a two-drum machine for gravity swinging.

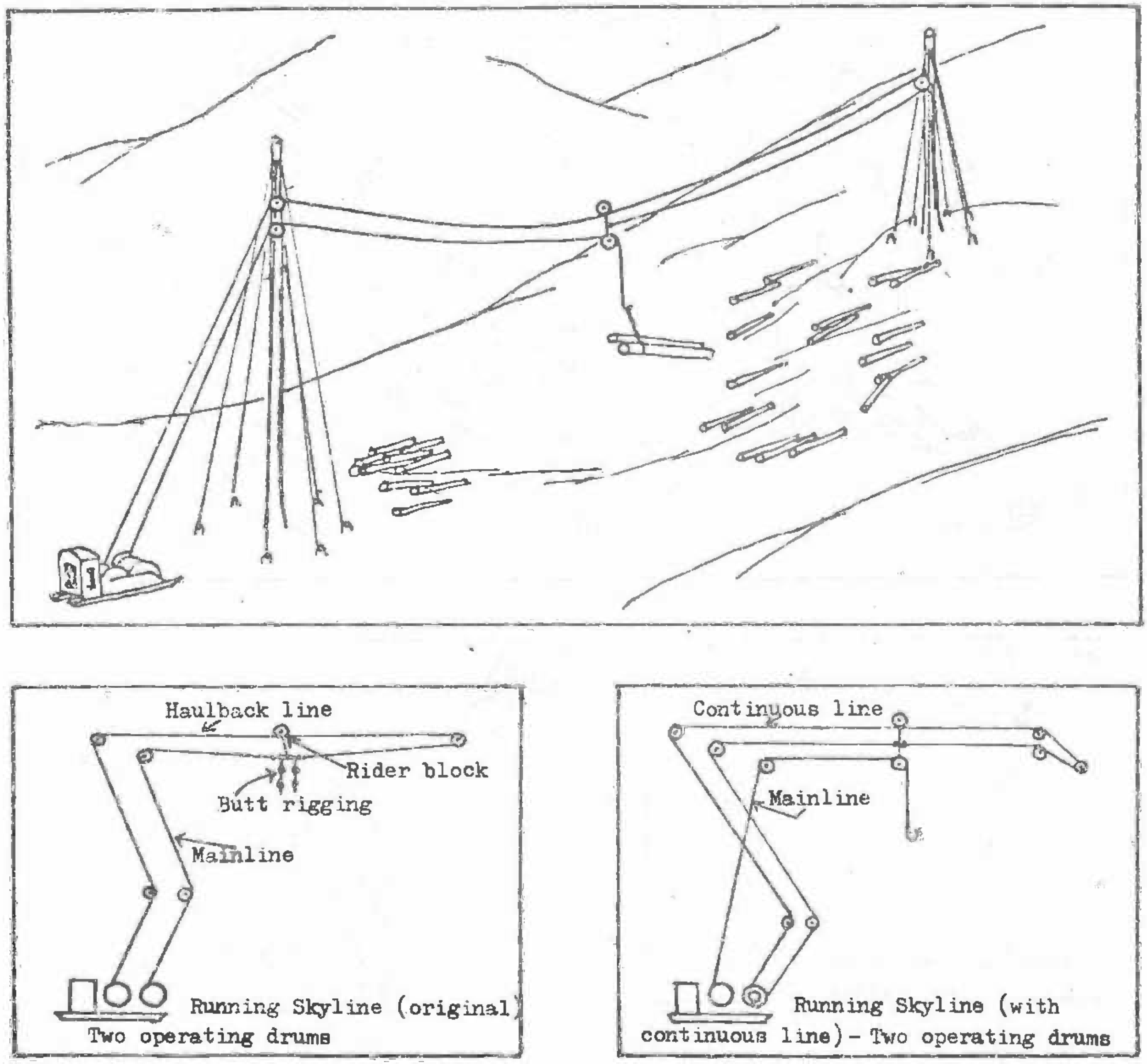
Yarding distances are dependent upon deflection. Where ground conditions warrant, distances of up to 500 m are possible.

2.3.9 Running Skyline (Figure 22)

This system can be used in a variety of ways and can be used in clearcut as well as partial cuts or thinnings. The system differs from highlead in that the haulback line is used as a running skyline, thus its position is reversed on the spar(s). Figure 22 shows a tailspar, but if deflection is suitable stumps may be used as the back end.

The normal method employs a two-drum yarder; however added lift is provided by braking the haulback as the mainline is brought in. Drum interlocks facilitate correct tensioning.

Figure 22 - Running Skyline (System)



Another version uses a three-drum interlock yarder and grapples are often used instead of chokers.

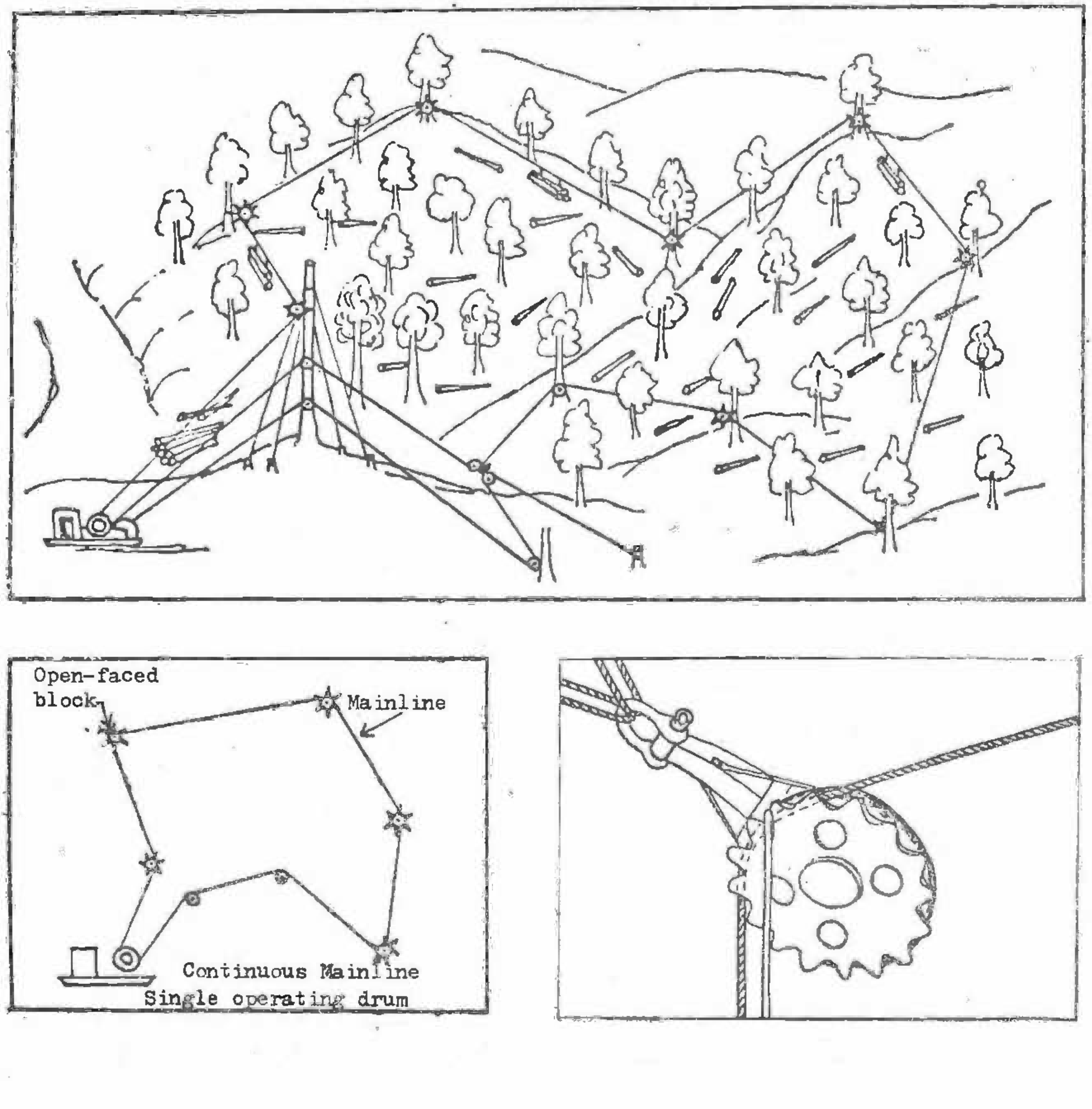
An important advantage is the short set-up/take-down time as in highlead if no tailspar is used. The narrow strip which can be logged is advantageous for thinning.

As in any skyline system attention must be paid to the stresses placed on the anchor stumps at the back end to ensure against failure.

2.3.10 Continuous Mainline (Figure 23)

This system is unique among cable configurations and is based on the ground lead system. It is designed for thinning at yarding distances of up to 400 metres and employs a special open-faced block. The logs are attached by chain or hemp rope to the mainline. A control line is used to tension the mainline. Single or double drum winches are used, as shown in the units of Figure 23.

Figure 23 - Continuous Mainline - Monocable (System)



There are many other cable configurations which have been or are currently in use. However, the basic problem is to determine which system to use in order to collect and transport logs efficiently under each set of conditions, having due regard to environmental and silvicultural factors.

Cable configurations are classified according to several factors, such as: gravity or all-terrain, skyline or non-skyline, standing skyline (tight skyline) or live skyline, using continuous lines or not, etc.

A classification of the major cable configurations is given in Table 4.

Table 4 - Classification of Cable Configurations

	Skyline		Non-skyline
	Standing	Live	
Gravity (downhill)	Snubbing Tyler	(Slack line)	
Uphill	Tyler (3 drums)		
All-terrain	Endless Endless Tyler North bend	Slack line	Ground lead High lead Running skyline Continuous mainline

▭ : Usually or always employs continuous line

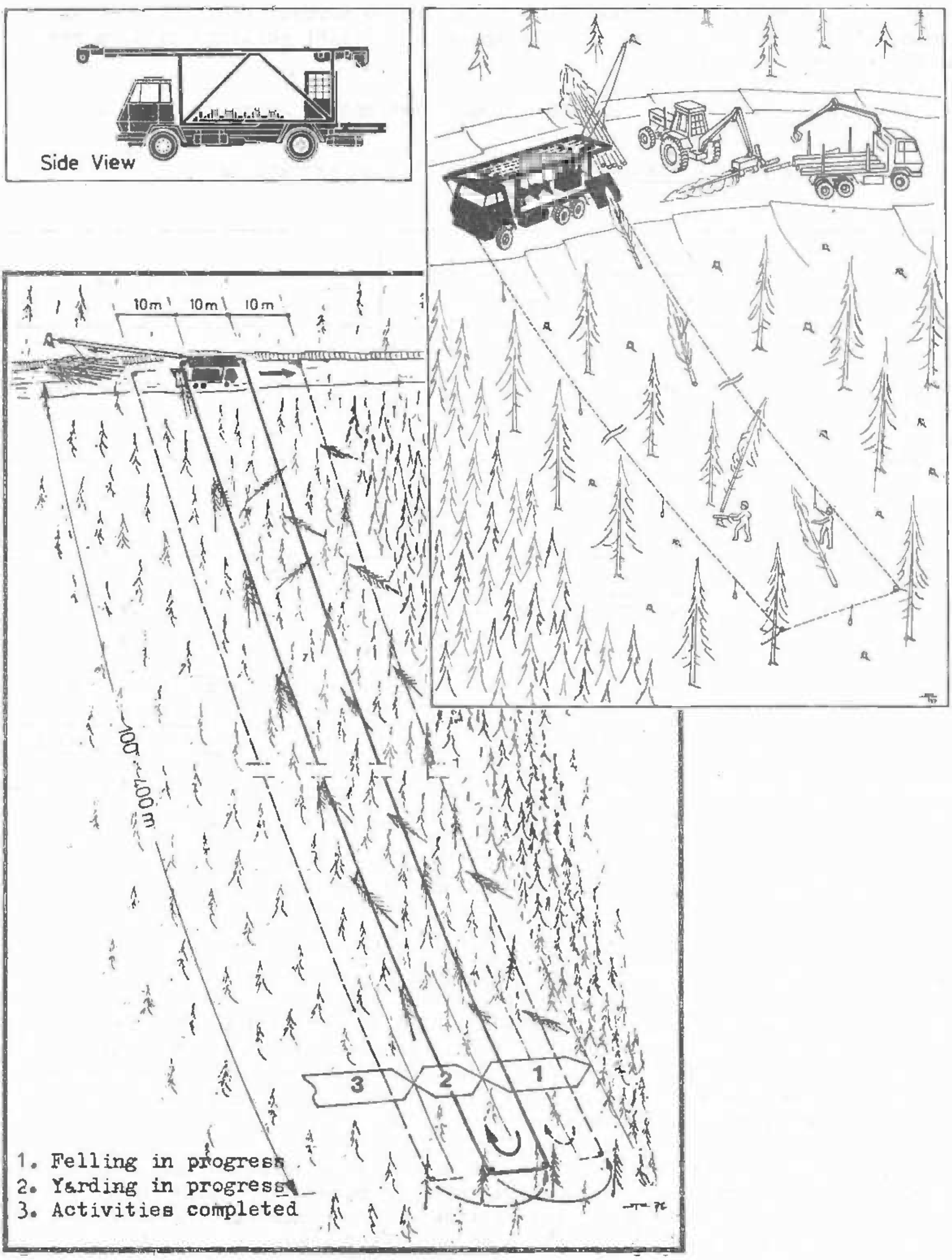
—— : Some versions employ continuous line

2.4 Yarding Trailers for Continuous Mainline System

The yarding trailer for a continuous mainline system is a relatively new Austrian development. The commercial manufacture of this trailer was begun in 1975. The system is unique in that it provides a "continuous flow" of trees or logs to the yarder (Figure 24) and is basically groundlead, being designed for thinning at yarding distances of up to 400 metres with a 10 meter spacing between the yarding strips.

Chain is used for the mainline although the original version used cable. The chokers are suspended from the chain and are moveable along each 20 meter section of the chain. Trees are yarded top first. When a turn of trees reaches the yarder the operator stops the chain, releases the turn and attaches it to an auxiliary line which is then used to yard the turn out of the way into a pile. The turn on the auxiliary line is released by remote control. While the chain is stopped, the chokerman attaches a turn of trees to the next choker. The chokerman and the yarder operator coordinate their activities through the use of a radio system. Trees are limbed and bucked at the road.

Figure 24 - Continuous Mainline System with a Yarding Trailer



Courtesy Steyr Forsttechnik

The crew consists of a minimum of two men: a machine operator and a chokerman. An additional chokerman is sometimes needed for setting chokers and/or for working with the auxiliary line decking operation. In the felling operation, the trees must be directed into or close to the yarding strip, the tops should point in the direction that the trees will be yarded (to lead) so that the yarding operation is as efficient as possible.

The general specifications for a yarding trailer are given in Table 5 and in Appendix 1.

Table 5 - Specifications for a Yarding Trailer for Continuous Mainline System (based upon Timber-veyor)

Maximum pulling power	60 kN (6 000 kp)
Maximum line speed	1.4 m/s
Maximum yarding distance	400 m
"Tower" height	4 m
Engine power	88 kW (120 hp)
Weight of complete unit	14 000 kg

2.5 Mobile Tower Yarders

Mobile tower yarders were developed about 20 years ago as an improvement on the wooden spar and yarder system in use on the west coast of North America at that time. Since their introduction, the mobile tower yarders have received wide acceptance due to their increased mobility and faster set-up and take-down time as compared to the old spar tree system.

More recently, European mobile tower yarders have been developed for cable cranes commonly used in Europe. Some European systems incorporate North American methods as well. Since the European systems are basically designed for smaller wood and lighter loads than North American systems, some of the European systems are being tried in North America for thinning in steep terrain. Smaller North American units have also been developed.

The systems described in this section have been classified as follows:

- Small Mobile Tower Yarders - Maximum mainline pulling power up to 100 kN (10 200 kp)
- Medium Mobile Tower Yarders - Maximum mainline pulling power over 100 kN (10 200 kp) and up to 300 kN (30 600 kp)
- Large Mobile Tower Yarders - Maximum mainline pulling power over 300 kN (30 600 kp)

All these systems consist of three main components:

- the tower
- the yarder
- the carrier

Although these three main components are common to all mobile tower yarders, there are also certain differences between these three classifications as regards design and application of this equipment. Therefore the main features for each classification have been described separately.

2.5.1 Small Mobile Tower Yarders (Figures 25 and 26)

General features

General features of the small mobile tower yarders are as follows:

- The tower and yarder usually come as a unit.
- The tower is laid down over the carrier for easy transport and is sometimes hinged to shorten its length.
- The tower is normally stabilized with two or three guylines.
- The yarder usually has three operating drums plus a strawline drum. The strawline is normally only used for laying out and changing the operating lines.
- When the carrier is a trailer, the power for the yarder may be included with the trailer unit or it may be provided by the machine which tows the unit.
- When the carrier is a truck, the power for the yarder is usually provided by the truck (power take-off).

The general specifications for small mobile tower yarders are given in Table 6 on Page 41. Some selected examples are given in Appendix 1.

Usage

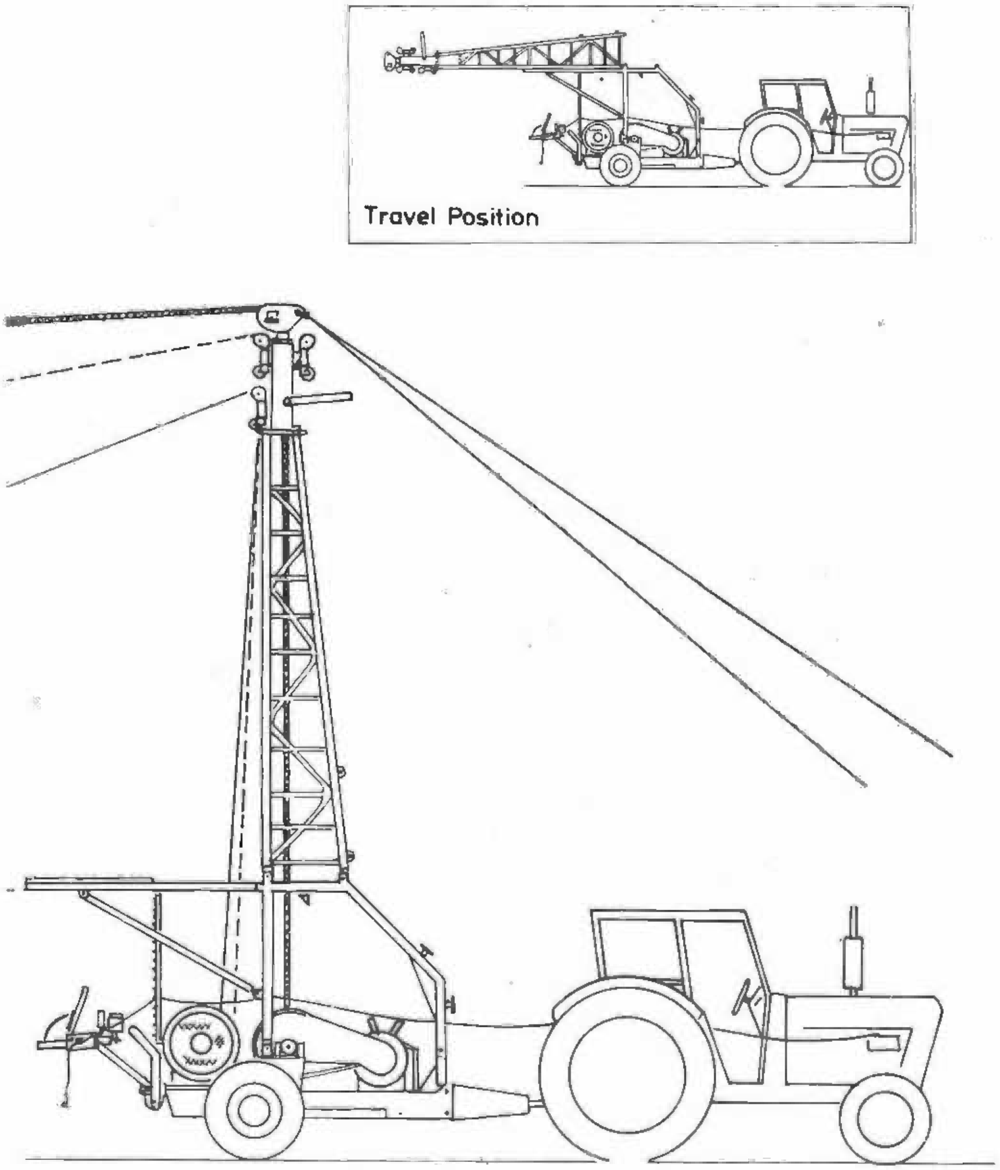
The small mobile tower yarders are designed for single or multispan skyline usage with a carriage (skyline crane), for lateral yarding. These systems are commonly used in thinnings and partial cuts. Present emphasis is on yarding distances of 300 to 600 metres and a minimum of intermediate supports.

The crew consists of two or more men depending upon the equipment and the operating conditions. The first two men required on the crew are a machine operator and a chokerman. The third man is usually a landing man, and the fourth is usually an additional chokerman.

The felling operations are the same as those described under Yarders (see Page 9).

Small mobile tower yarders are designed for temporary use at one or more landings in or at the edge of an operating area. The landing is normally at a truck road. However, some types of these yarders can be used off the road to log isolated patches of forest on steep terrain, which lie within areas which are to be logged with ground equipment. In such situations the wood is yarded and bunched for subsequent transport to the roadside by ground equipment. In this way road construction can be reduced.

Figure 25 - Small Mobile Tower Yarder - Trailer Mounted

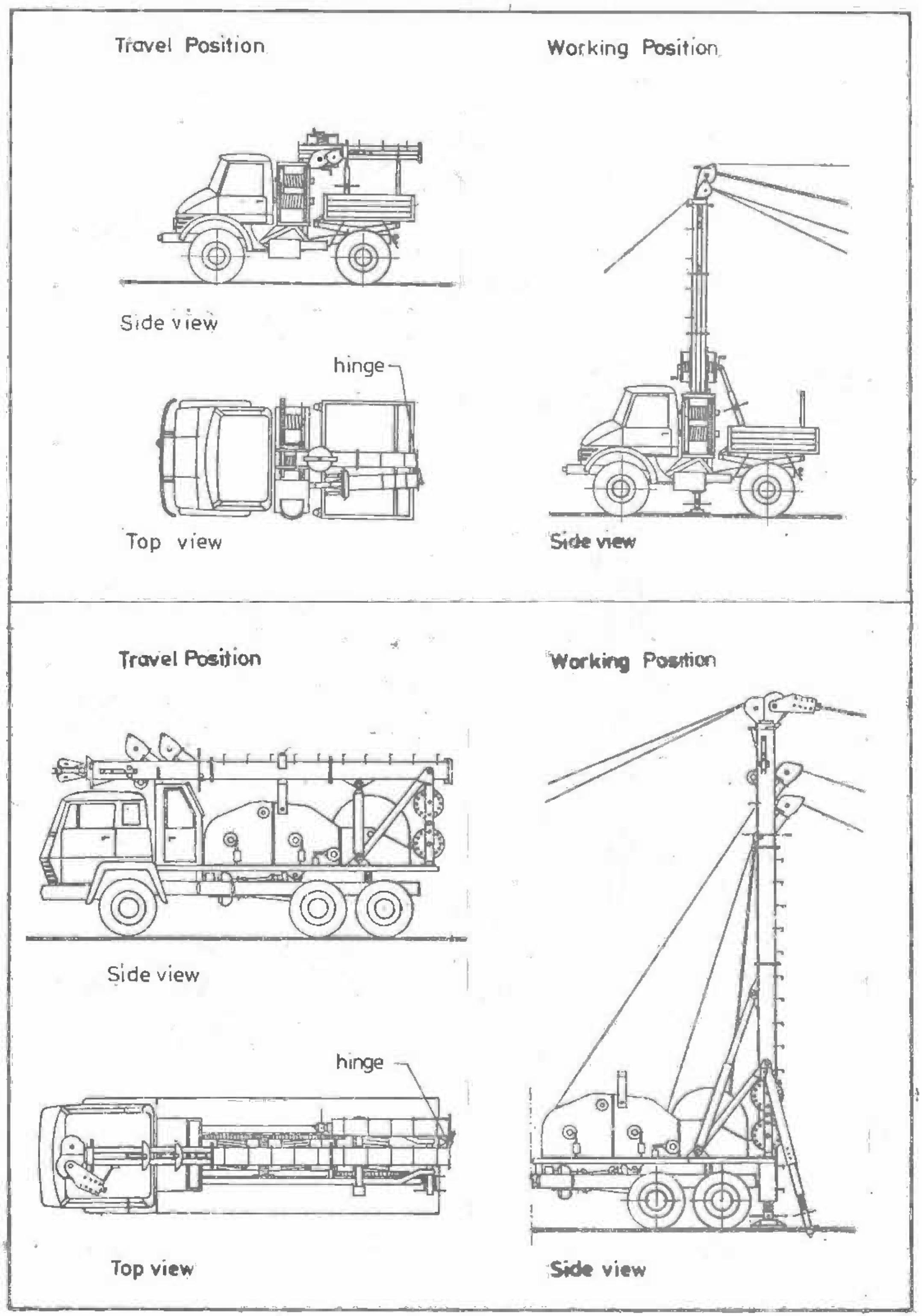


Travel Position

Working Position

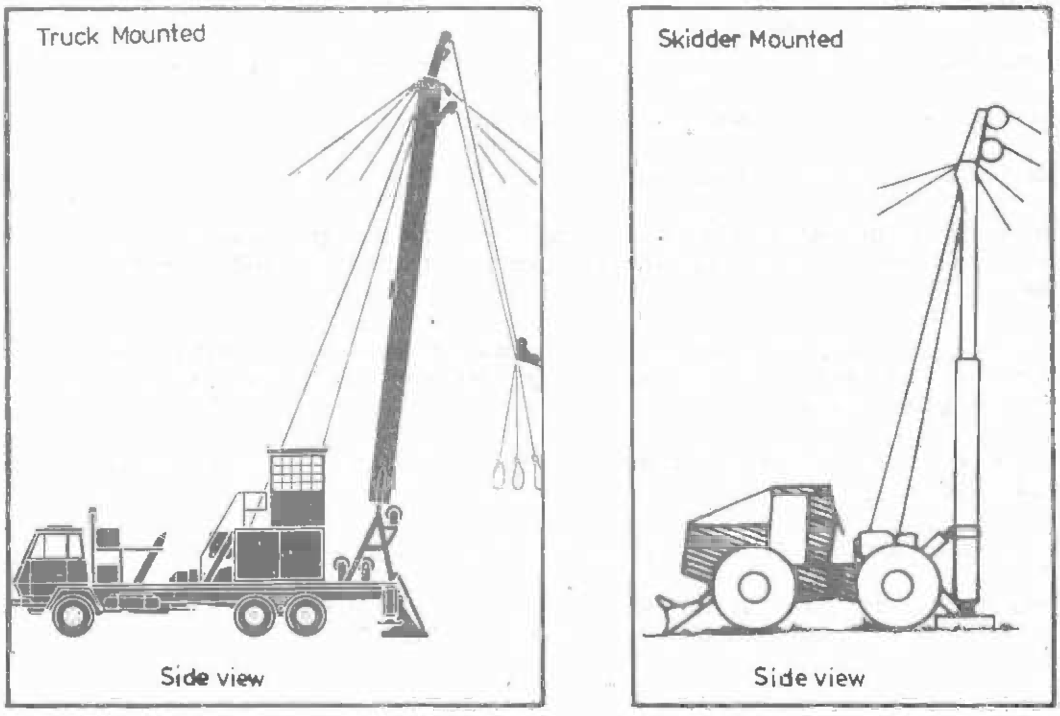
Courtesy James Jones & Sons Limited

Figure 26 - Small Mobile Tower Yarders - Truck Mounted

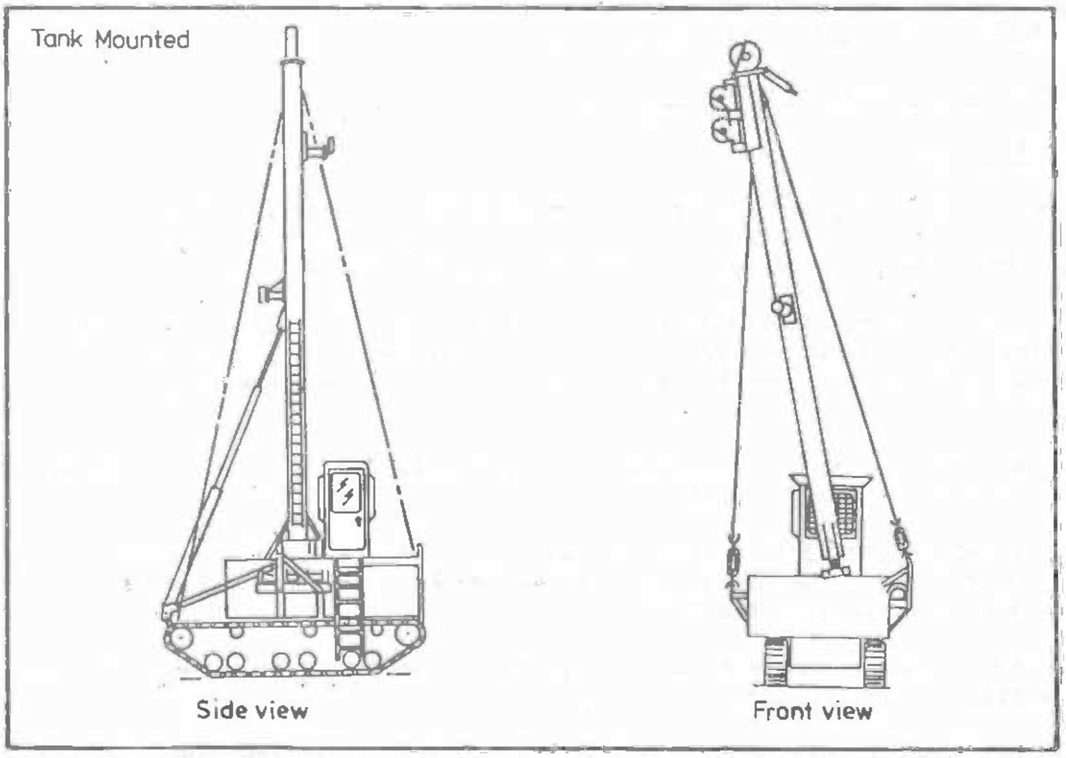


Courtesy Reinhold Hinteregger

Figure 27 - Medium Mobile Tower Yarders



Courtesy Steyr Forsttechnik



Courtesy S. Madill Limited

2.5.2 Medium Mobile Tower Yarders (Figure 27)

General features

General features of the medium mobile tower yarder are as follows:

- The tower and yarder usually come as a unit.
- The tower can be laid down over the carrier for easy transport.
- The tower is normally stabilized with three to six guylines depending upon the tower height, tower design and the forces exerted upon the tower.
- The yarder usually has two to four operating drums plus a strawline drum. The strawline is normally only used for laying out and changing the operating lines.
- The self-propelled carrier can be a skidder, truck, or the bases of crawler or tank units.
- The carrier and yarder usually are powered by the same engine.

The general specifications for medium mobile tower yarders are given in Table 7 on Page 42. Some selected examples are given in Appendix 1.

Usage

The medium mobile tower yarders are basically designed for highlead and skyline usage which is common on the west coast of North America. This is described below, under "Large Mobile Tower Yarders". Some of these yarders are also designed for the usage described above under small mobile tower yarders.

2.5.3 Large Mobile Tower Yarders (Figure 28)

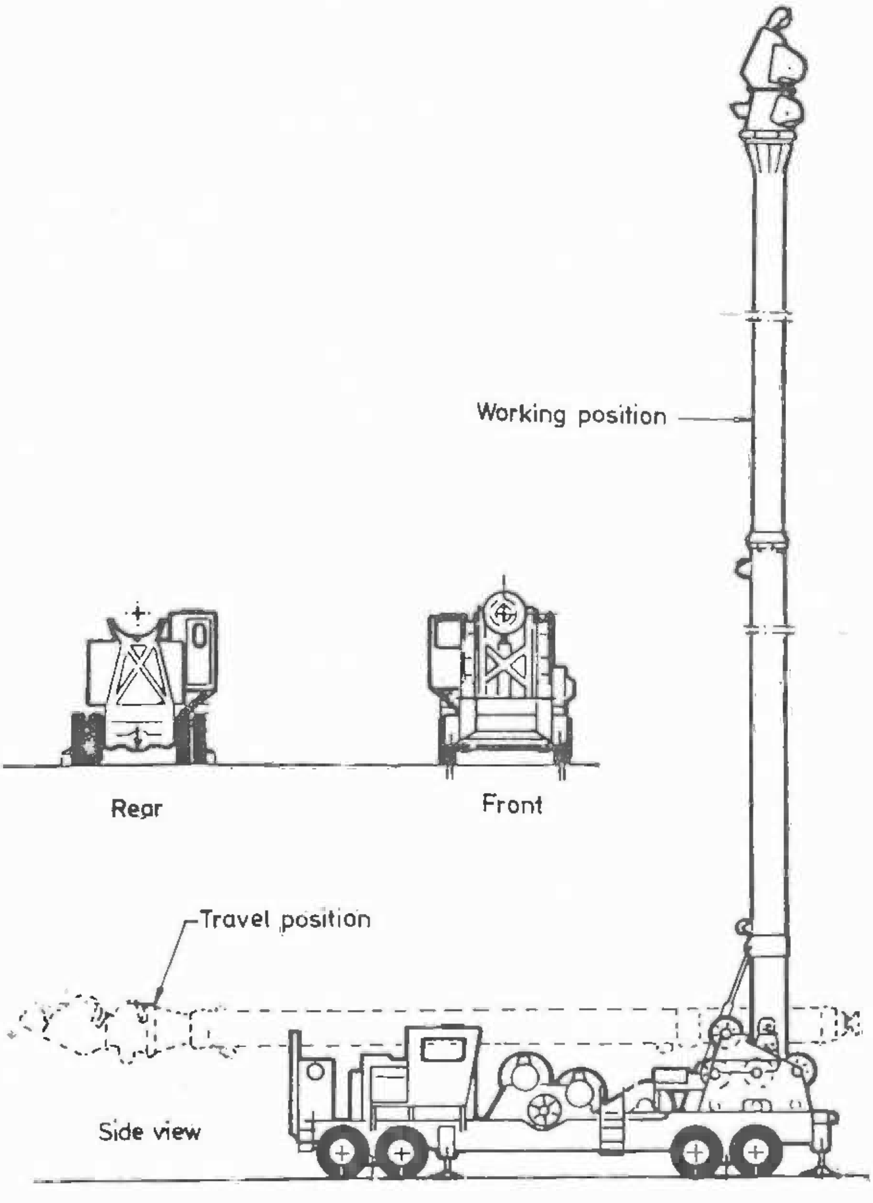
General features

General features of the large mobile tower yarders are as follows:

- The steel tower can be telescoping or non-telescoping.
- The tower is normally stabilized with three to eight guylines although some towers can use up to twelve guylines. The number of guylines used is dependent upon the tower height, tower design and the forces exerted upon the tower.
- The carrier (Figure 29) is available as a trailer unit or as a self-propelled rubber-tyred or tracked unit.
- The yarder (Figure 30) is available with two to four operating drums plus a strawline drum. The strawline is normally only used for layout out and changing the operating lines.
- The carrier and yarder are powered by the same engine, except when the carrier is a trailer.

The general specifications for large mobile tower yarders are given in Table 8 on Page 42. Some selected examples are given in Appendix 1.

Figure 28 - Large Mobile Tower Yarder - Telescoping Steel Tower and Yarder on Self-Propelled Rubber-Tyred Carrier



Courtesy Washington Iron Works

Figure 29 - Carriers for Large Mobile Tower Yarders

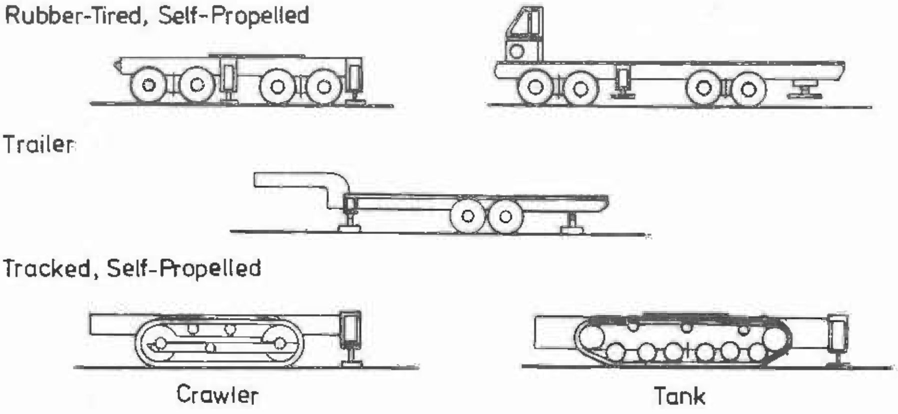
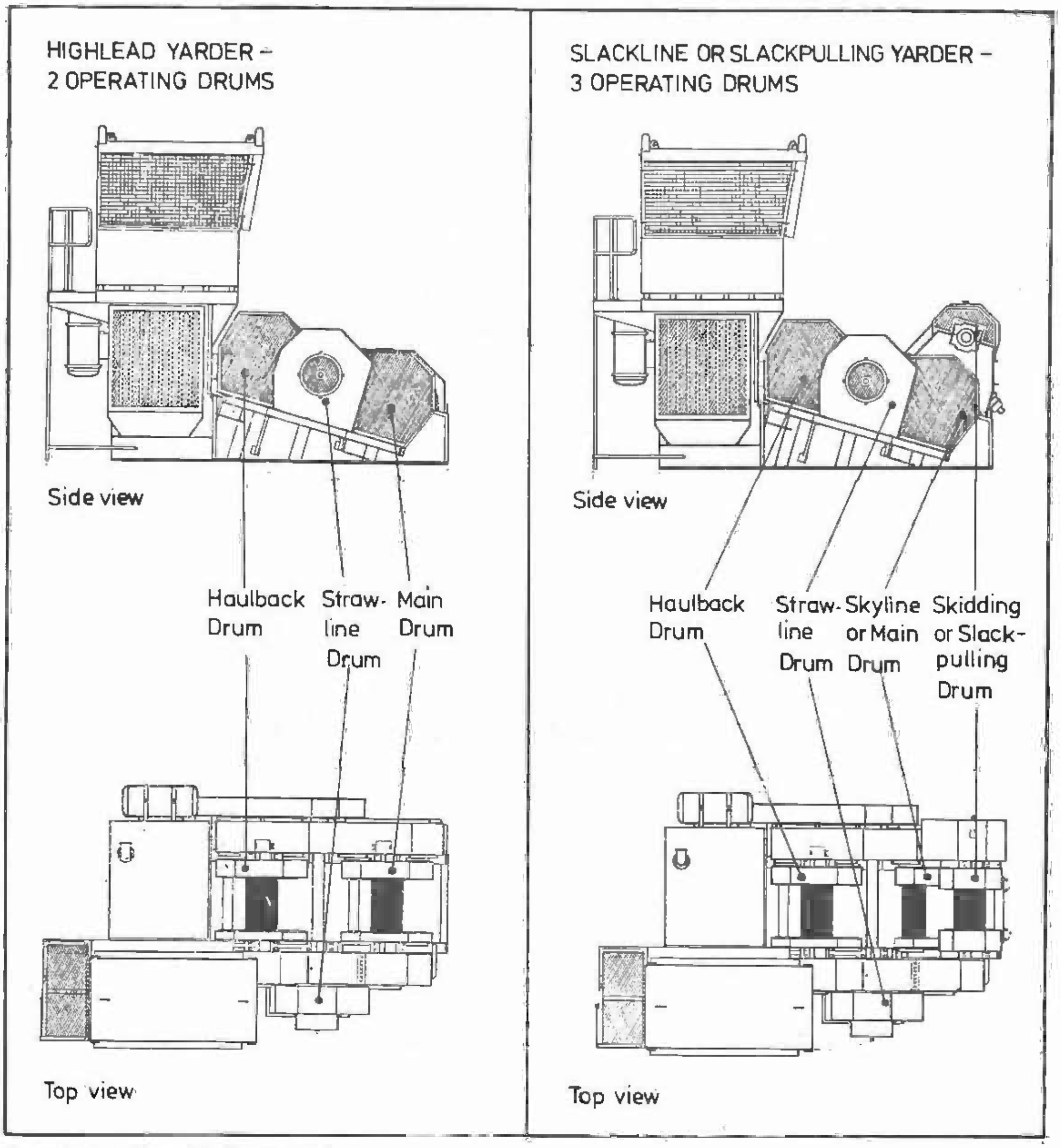


Figure 30 - Yarders for Large Mobile Tower Yarders

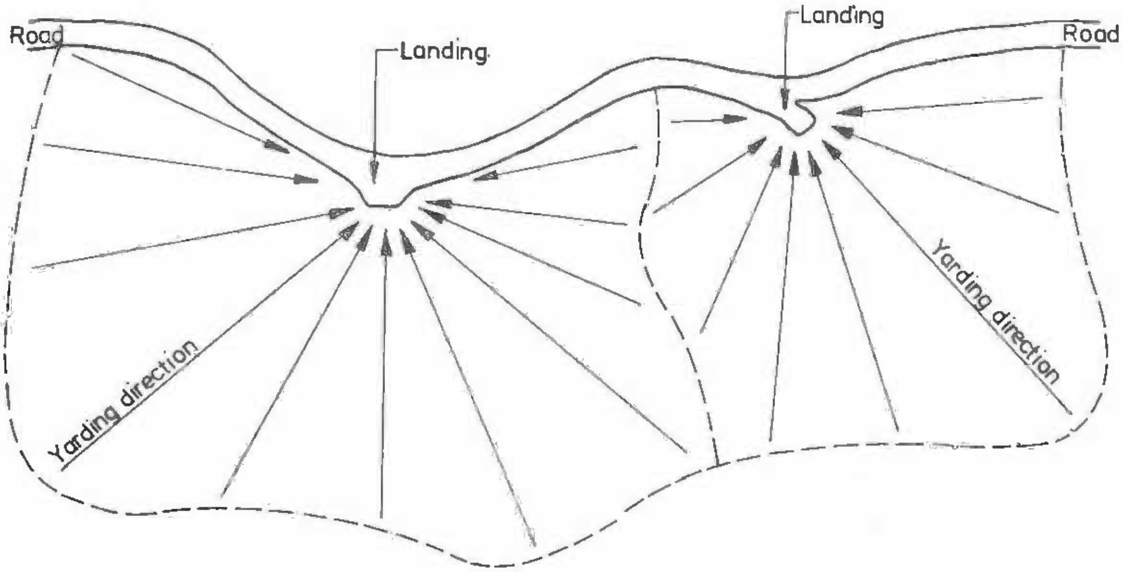


Courtesy Skagit Corporation

and the loading machine in order to keep the operations as synchronized as possible. In such cases, the productivity of the loader is limited to the productivity of the yarder.

There are so many different cable configurations used with the large mobile tower yarders that it is impractical to try to describe them all. However, since the highlead, live skyline (slackline versions) and standing skyline (north bend version) configurations give a good cross section of the various alternatives, these configurations will be described below, and these have also been described in the section on Yarders.

Figure 31 - Logging Pattern for Most Large (and Medium) Mobile Tower Yarders



2.5.4 Highlead (Figure 32)

This system, the most common on the west coast of North America, requires only a two-drum yarder to handle the mainline and haulback lines. This is basically an uphill yarding system for use in clearcuts (haul line) but is also used for downhill yarding. The logging pattern shown in Figure 31 is typical for highlead logging. No carriage is used. The mainline and haulback line are connected with a set of swivels and chain, called butt rigging (Figure 43 on Page 53), which is designed to accommodate two or three chokers. Maximum yarding distance is normally about 300 meters. The logs being yarded usually drag on the ground.

The crew consists of four or more men: one machine operator, one landing man (chaser), one man who oversees the yarding activities, and one or more chokermen.

Usage

The large mobile tower yarders being manufactured today are basically designed for clearcut logging of the large timber in the steep terrain found on the west coast of North America. Since these systems are designed to handle large, heavy wood, they have found acceptance in other parts of the world where such wood is found in terrain which requires the use of cable systems. Yarding distances of 200 to 400 metres are most common, although this can vary greatly depending upon the equipment, terrain and other conditions, and the cable configuration used. A description of the major cable configurations for large mobile tower yarders is given later on in this section.

The crew normally consists of three to seven men depending upon the cable configuration and/or carriage used. More details are given in the descriptions of the different configurations.

In the felling operations in large timber it is important to fell the trees in a manner that will minimize breakage and the resultant value loss. In partial cuts and thinnings it is also necessary to direct the trees so that the lateral yarding to the skyline strip is as efficient as possible. In clearcuts the most common felling pattern is to direct the trees parallel with the contour as long as the terrain allows it. When sharp ridges occur across the slope, it is normally necessary to change the felling direction to avoid excessive breakage. The trees should be felled parallel with each other to minimize breakage. In felling operations in small timber, breakage is normally less since the small stems are more resilient. In addition, the value loss when breakage occurs is normally less in a small stem. Exceptions can be special products such as poles and pilings.

When using chokers, the felling direction, in relation to the yarding direction, is not as critical to productivity as when using a grapple[1/]. However, it is advantageous (although not always possible) for the felling direction to be parallel with the yarding direction, especially when little or no lift can be applied to the leading ends of the logs since hang-ups will be reduced.

When using grapples with mobile towers it is most desirable that the trees are felled at right angles to the direction of yarding because this allows a greater number of logs and a greater portion of each log to be exposed to each yarding strip. This permits the yarding strips to be farther apart and thereby reduces the number of yarding strips required per operating area.

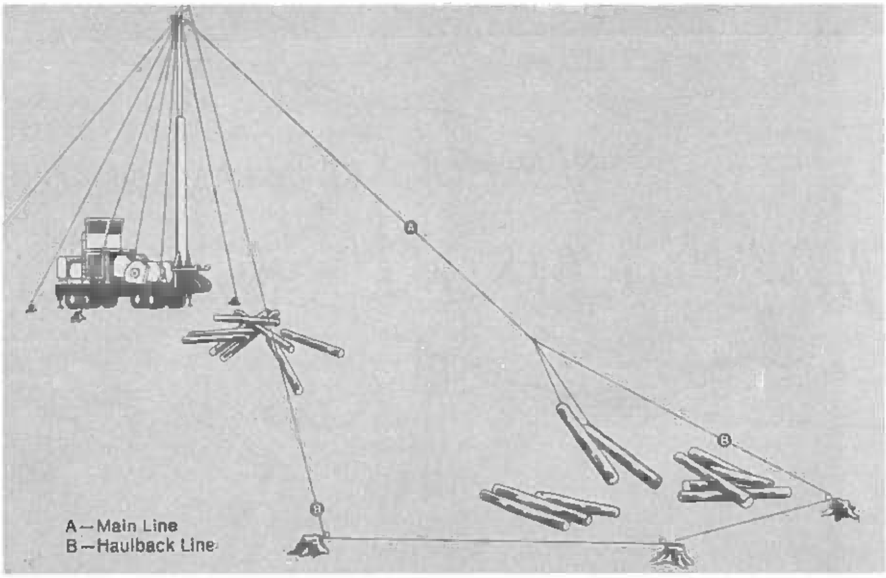
An important difference between using chokers and grapples is the effective width of the yarding strips. The chokermen can pull the chokers out to either side of the yarding strip to get logs. This increases the effective width of each yarding strip. A grapple can only pick up logs which lie under the grapple.

The effective width of a grapple yarding strip is relatively limited. However, the width of a yarding strip can be increased by side blocking. The yarding strips usually radiate out from the landings as shown in Figure 31.

Large mobile tower yarders are designed for temporary location at one or more landings in or at the edge of an operating area. Since the yarding machines are somewhat fixed in position and have no swing capabilities, the incoming logs are all placed in the same location on the landing. When the landing is on a truck road, a loader is normally kept at the landing to keep it open for incoming logs and to load logs on to trucks. In planning the operations it is important to consider the difference in productivity between the yarder and the loading machine in order to keep the operations as synchonized as possible. In such cases, the productivity of the loader is limit ed to the productivity of the yarder.

[1/] A grapple/carriage combination is shown in Figure 47b.

Figure 32 - Highlead with a Large (or Medium) Mobile Tower Yarder - Two Operating Drums



Courtesy Skagit Corporation

2.5.5 Live Skyline (Figure 33)

These systems use a carriage and require a yarder with two or more drums depending upon the configuration used. If the carriage used is such that the chokers are attached to it, as in Figure 44, the mainline must be lowered in order to reach the logs, therefore the system is best suited for a clearcut operation.

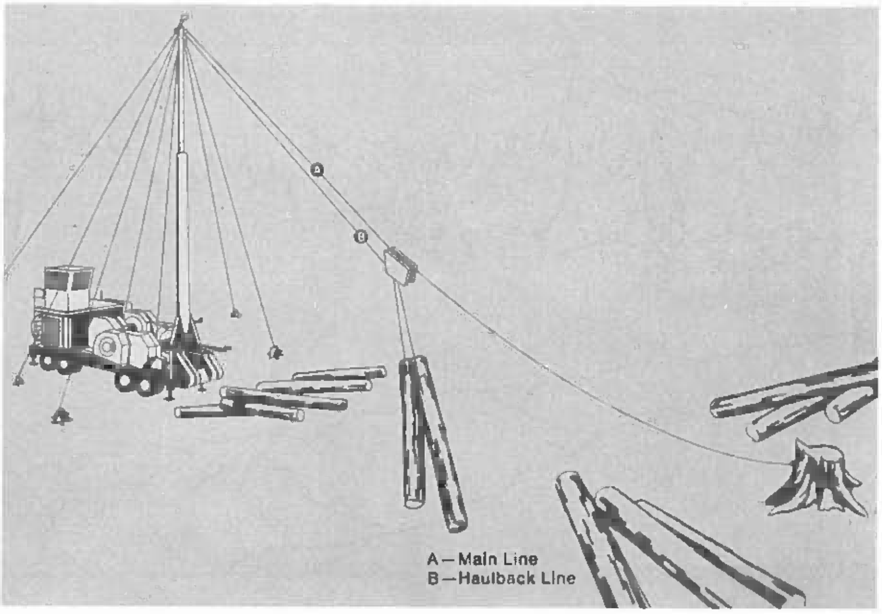
If the skidding line can be pulled out of the carriage (Figures 45, 46 and 47a on Pages 54 and 56 respectively), this system is better adapted for thinning, or partial cutting. When using two-drum yarders the system is normally only for uphill yarding with the carriage returning to the operating area by gravity (Figure 33a). When using yarders with three or more operating drums, the system can be used for uphill and downhill yarding (Figure 33b). Maximum yarding distance is about 750 metres.

Compared to the highlead system, skyline systems have the advantage of being able to lift the leading end of the logs, or the entire logs, clear of obstacles on the ground. In addition, using gravity to return the carriage to the operating area has the advantage of a short cycle time due to the rapid return (can exceed 25 m/s) of the carriage to the operating area.

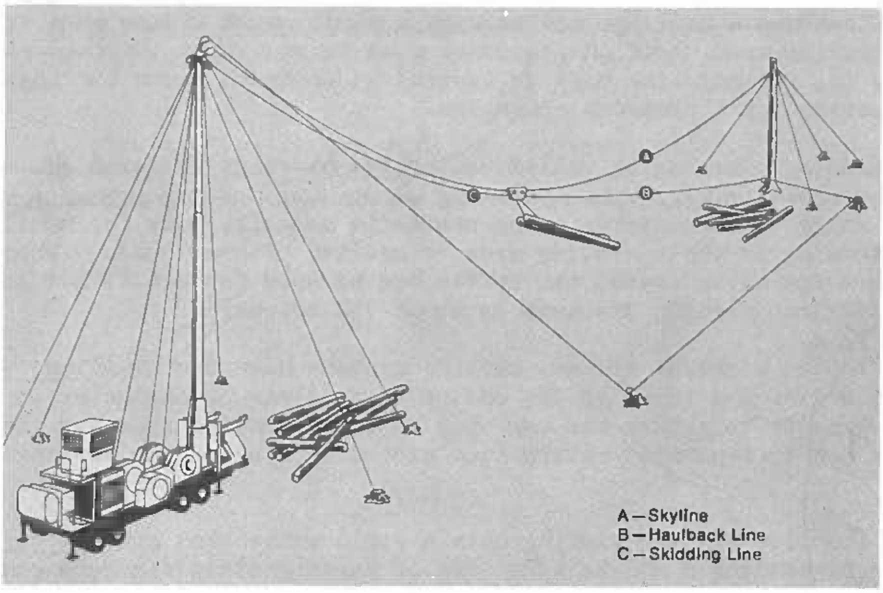
The crew for live skyline yarding with a radio controlled grapple carriage can be as few as three men (including a man to take care of yarding strip changes) since there is no need to have a man at the landing or for setting chokers. The crew for live skyline yarding using a choker carriage normally consists of five or more men.

Figure 33 - Live Skyline with a Large (or Medium) Mobile Tower Yarder

a. Gravity - Two Operating Drums



b. Slack Line - Three Operating Drums



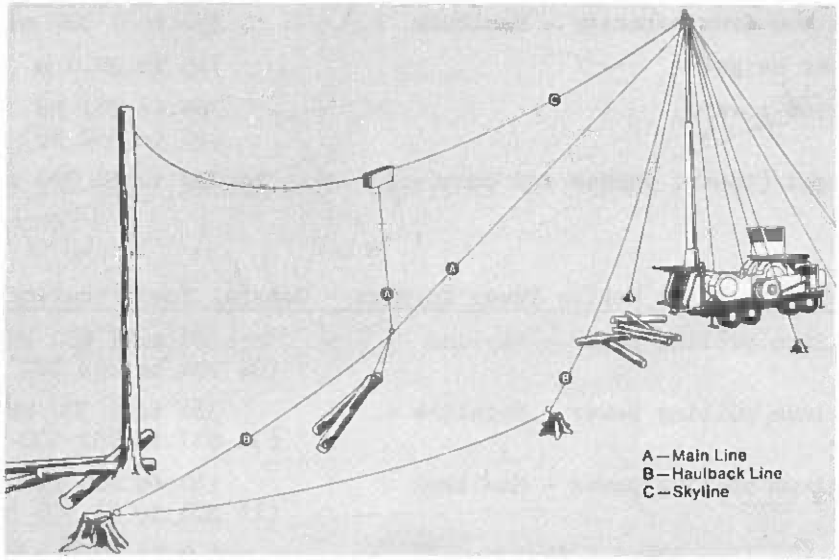
Courtesy Skagit Corporation

2.5.6 Standing Skyline (Figure 34)

These systems usually require a yarder with two or more drums depending upon the configuration used. If the skyline is not controlled by one of the yarder drums, only one drum is required to operate some standing skyline systems (gravity). These systems use a carriage (Figures 45 and 46 on Page 54, and can be used for thinning, and for partial cutting or clearcutting with the same limitations as in the live skyline systems. Some standing skyline systems, such as the north bend system shown in Figure 34, are used for swinging decked logs. Maximum yarding distance is normally about 600 metres, although some yarders can yard up to 1 200 metres.

The crew for a standing skyline system usually consists of five or more men.

Figure 34 - Standing Skyline Yarding with a Large (or Medium) Mobile Tower Yarder - Two Operating Drums plus Skyline (North Bend configuration)



Courtesy Skagit Corporation

Table 6 - Small Mobile Tower Yarders - General Specifications

Maximum load capacity	600 to 2 500 kg
Maximum pulling power - Skyline	20 to 200 kN (2 000 to 20 400 kp)
Maximum pulling power - Mainline	10 to 70 kN (1 000 to 7 100 kp)
Maximum pulling power - Haulback	10 to 60 kN (1 000 to 6 100 kp)
Maximum line speed - Skyline	0.5 to 5.0 m/s
Maximum line speed - Mainline	3.5 to 8.0 m/s
Maximum line speed - Haulback	4.5 to 8.0 m/s
Maximum drum capacity - Skyline	300 to 800 m
Maximum drum capacity - Mainline	300 to 1 200 m
Maximum drum capacity - Haulback	600 to 1 600 m
Tower height	4.5 to 10.0 m
Engine power	19 to 186 kW (25 to 250 hp)
Weight (tower, yarder and carrier)	2 000 to 20 000 kg

Table 7 - Medium Mobile Tower Yarders - General Specifications

Maximum pulling power - Skyline	170 to 500 kN (17 300 to 51 000 kp)
Maximum pulling power - Mainline	110 to 280 kN (11 200 to 28 500 kp)
Maximum pulling power - Haulback	100 to 240 kN (10 200 to 24 500 kp)
Maximum line speed - Skyline	4.0 to 10.0 m/s
Maximum line speed - Mainline	4.0 to 16.0 m/s
Maximum line speed - Haulback	5.0 to 16.0 m/s
Maximum drum capacity - Skyline	200 to 1 500 m
Maximum drum capacity - Mainline	150 to 1 300 m
Maximum drum capacity - Haulback	350 to 1 300 m
Tower height	7.5 to 20.0 m
Engine power	45 to 261 kW (60 to 350 hp)
Weight (tower, yarder and carrier)	14 000 to 50 000 kg

Table 8 - Large Mobile Tower Yarders - General Specifications

Maximum pulling power - Skyline	340 to 1 600 kN (34 700 to 163 100 kp)
Maximum pulling power - Mainline	310 to 1 300 kN (31 600 to 132 500 kp)
Maximum pulling power - Haulback	110 to 880 kN (11 200 to 89 700 kp)
Maximum line speed - Skyline	4.0 to 10.0 m/s
Maximum line speed - Mainline	4.0 to 13.0 m/s
Maximum line speed - Haulback	9.0 to 30.0 m/s
Maximum drum capacity - Skyline	500 to 900 m
Maximum drum capacity - Mainline	300 to 900 m
Maximum drum capacity - Haulback	900 to 1 800 m
Tower height	15 to 37 m
Engine power	224 to 485 kW (300 to 650 hp)
Weight (tower, yarder and carrier)	30 000 to 120 000 kg

2.6 Running Skyline Swing Yarders

Running skyline swing yarders (Figure 35) have received rapid acceptance since their introduction in the Pacific Northwest region of North America at the end of the 1960's.

This system has the advantage of being very mobile, has a swinging boom and normally uses a slackpulling carriage with chokers (Figure 47a on Page 56), or with a grapple (Figure 47b on Page 56).

Running skyline swing yarders are designed in the following way:

- The three main components (tower, yarder and carrier) come as a complete unit.
- The leaning steel tower is normally of lattice construction.
- The leaning steel tower is normally stabilized with two guylines.
- The yarder has three operating drums:
    - 2 mainline drums (or a mainline drum and a slackpulling drum)
    - 1 interlocked and tensioned haulback drum.

  In addition the yarder has a strawline drum. The strawline is normally only used for laying out and changing the operating lines.
- The yarder and the leaning steel tower are mounted on a swing assembly on the carrier and the entire unit is self-propelled.
- The self-propelled carrier is either rubber-tyred or tracked.
- The carrier and yarder are powered by the same engine.

The general specifications for running skyline swing yarders are given in Table 9 on Page 46.

Some selected examples are given in Appendix 1.

To take advantage of the mobility of this yarding system, the harvesting operations can be planned so that the running skyline swing yarder can move along the road and pile the yarded logs on the road behind it as shown in Figure 36. This is especially applicable when using a grapple carriage in a clearcut area. Note that the trees are shown to be felled at right angles to the yarding direction for grapple yarding. Yarding can be uphill or downhill.

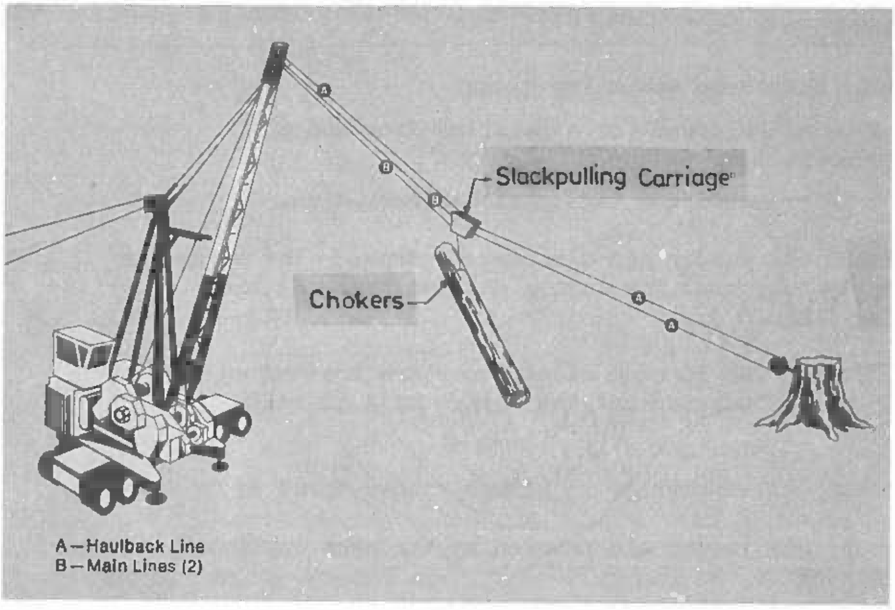
Piling the logs on the road eliminates the need for large landing areas. This also eliminates the need to keep a loading machine at the landing as compared to the situation when stationary cable systems are used. With a running skyline swing yarder the loader can move in after the yarder has finished the area, and load the logs out on a continuous basis (progressing from B to A as shown in Figure 36).

If the road system is such that logs can be hauled out in the opposite direction, the loading and transportation can begin before the yarder has finished in the operating area (in this case progressing from A to B as shown in Figure 36).

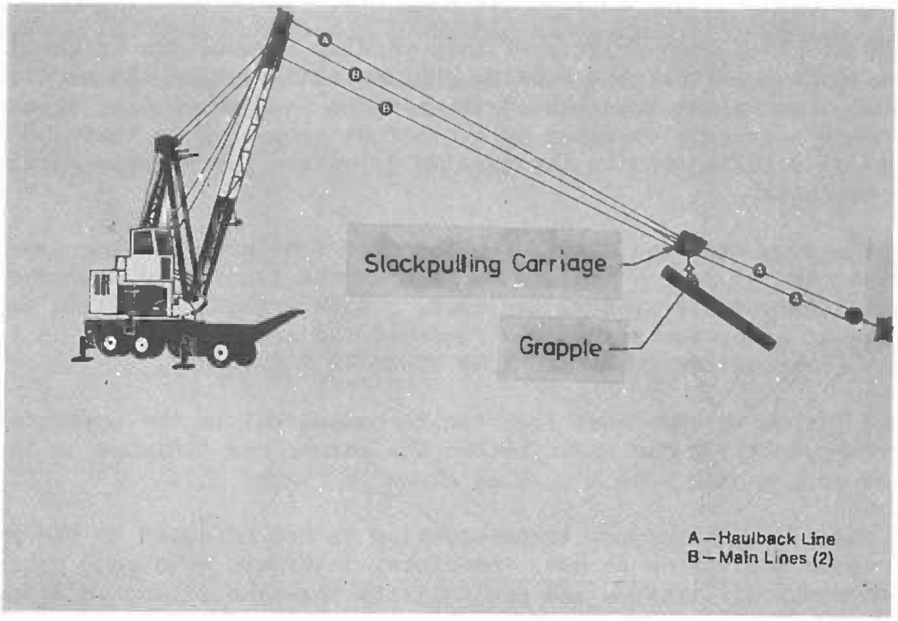
In either case the loading and transportation is not affected by the yarder's productivity and these activities do not, therefore, interfere with each other. This permits better equipment utilization and productivity than the situation described for large mobile tower yarders (see Page 35).

Figure 35 - Running Skyline Swing Yarders

a. Slackpulling Carriage with Chokers

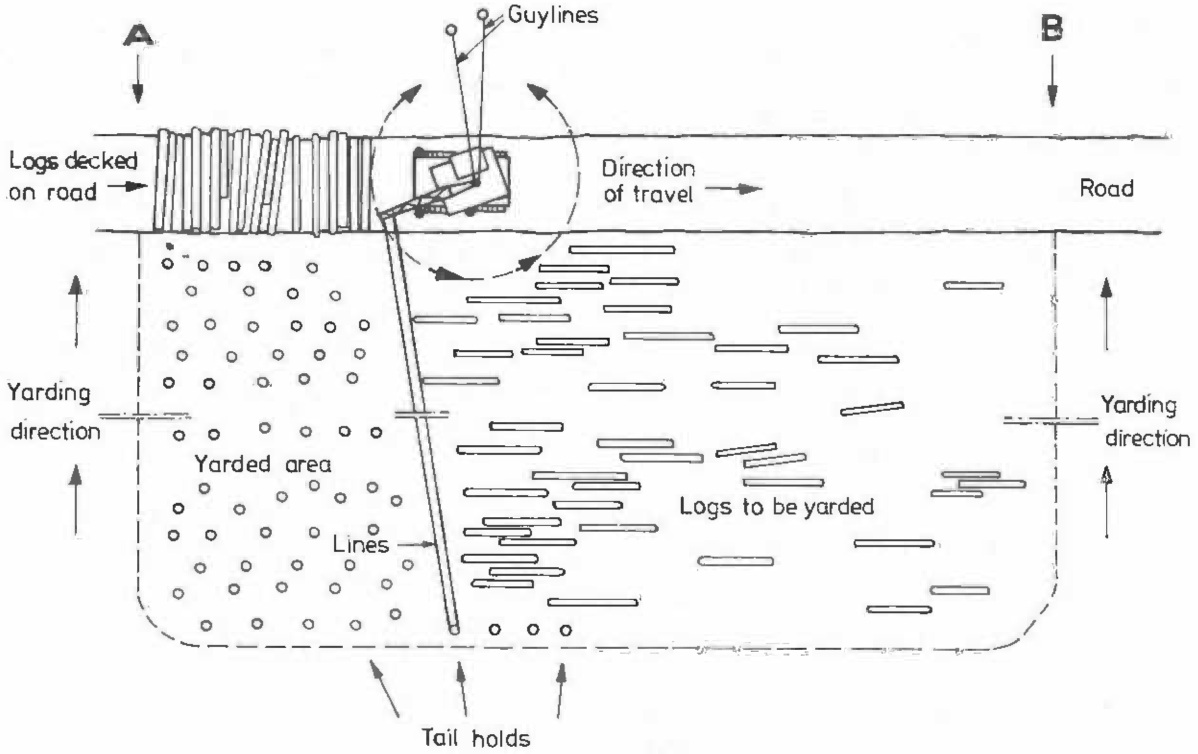


b. Slackpulling Carriage with Grapple



Courtesy Skagit Corporation

Figure 36 - Running Skyline Swing Yarder Using a Grapple in a Clearcut



Although a running skyline system need only consist of an interlocked mainline and haulback, in practice it consists of two mainlines (a mainline and slack-pulling line) and a haulback line. The haulback is tensioned to provide lift. By employing two mainlines it is possible to control the slackpulling operations from the yarder. The load is supported by the running skyline (which is also the haulback) plus the haulback and the mainline(s). Since the load is supported by the equivalent of two lines, these lines can be lighter than any single line required to support the load. The best and most efficient means of maintaining the tension between the mainlines and haulback and at the same time conserving as much as possible of the power used in maintaining this tension, is through the use of an interlock. This tension system allows the deflection of the lines to increase with an increased load, rather than increasing the tension of the lines. This minimises overloading the lines and the running skyline anchors.

As with all skyline systems, running skylines require proper deflection. Deflection is affected by topography but can be improved by the proper location of the harvesting road. Once the road has been located, the only means of increasing deflection is to elevate the single tail block, since intermediate supports are not used.

Since this system uses a slackpulling carriage with chokers or a grapple, it can be used for thinning, partial cutting and clearcutting. When using a grapple in a clearcut, the machine operator handles all yarding and decking operations from the cab of the yarder. When the operator has a good view of the harvesting area he positions the grapple over the logs, picks up the logs, yards them to the decking area, places them in the deck by opening the grapple and returns the grapple to the logging area to pick up the next log(s).

The cycle is repeated until it is necessary to move the yarder or the tailhold. If the operator cannot see the logs to be picked up, the man in the logging area guides him to the logs by giving him directions over a radio.

When using a grapple the workers do not need to get near the operating lines. Because of this it is possible to safely operate the grapple system at night by illuminating the operating area with lights. This greatly increases the available operating time which is advantageous, due to the high investment cost of the yarder.

The crew consists of two or three men in a grapple operation: one yarder operator, two or more men in the logging area, and one man at the landing. The men in the logging area are responsible for making the tailhold changes. A mobile tailhold, normally mounted on an old crawler tractor, is often used in a grapple operation in a clearcut area. This allows the tailhold to be moved quickly and easily.

The felling operations are the same as described under Large Mobile Tower Yarders.

There are running skyline swing yarders which are capable of yarding distances of more than 650 metres. However, in the Pacific Northwest it is common practice to use a yarding distance of 200 to 225 metres.

Running skyline swing yarders can also be used in other cable configurations, such as highlead, gravity, etc.

Some running skyline yarders are used with the carriers and towers described under Large Mobile Tower Yarders.

Table 9 - Running Skyline Swing Yarders
General Specifications

Maximum pulling power - Mainlines	220 to 550 kN (22 400 to 56 100 kp)
Maximum pulling power - Haulback	70 to 530 kN (7 100 to 54 000 kp)
Maximum line speed - Mainlines	4.0 to 15.0 m/s
Maximum line speed - Haulback	4.0 to 16.0 m/s
Maximum drum capacity - Mainlines	450 to 850 m
Maximum drum capacity - Haulback	700 to 1 500 m
Tower height	13.5 to 19.0 m
Engine power	142 to 343 kW (190 to 460 hp)
Weight (tower, yarder and carrier)	40 000 to 90 000 kg

Table 10 - Comparison of the Different Cable Yarding System Classifications - General Specifications

Summary of Tables 1 through 9 (excluding Table 4)

Classification	Independent Bunching Winches	Machine-mounted Winches	Yarders	Yarding Trailers for Continuous Mainline System
Maximum pulling power	5 to 45 kN (500 to 4 500 kp)	10 to 735 kN (1 000 to 75 000 kp)	10 to 150 kN (1 000 to 15 000 kp)	60 kN (6 000 kp)
Maximum line speed	0.4 to 1.5 m/s	0.4 to 2.5 m/s	2.0 to 10.0 m/s	1.4 m/s
Maximum drum capacity	50 to 25 m	30 to 800 m	600 to 4 200 m	400 m
"Tower" height	-	0 to 5.5 m	-	4 m
Engine power	4 to 37 kW (5 to 50 hp)	11 to 336 kW (15 to 450 hp)	7 to 149 kW (10 to 200 hp)	88 kW (120 hp)
Weight	40 to 750 kg	100 to 2 000 kg	500 to 7 000 kg	14 000 kg

Classification	Small Mobile Tower Yarders	Medium Mobile Tower Yarders	Large Mobile Tower Yarders	Running Skyline Swing Yarders
Maximum pulling power - Skyline	20 to 200 kN (2 000 to 20 400 kp)	170 to 500 kN (17 300 to 51 000 kp)	340 to 1 600 kN (34 700 to 163 100 kp)	- -
Maximum pulling power - Mainline	10 to 70 kN (1 000 to 7 100 kp)	110 to 280 kN (11 200 to 28 500 kp)	310 to 1 300 kN (31 600 to 132 500 kp)	220 to 550 kN (22 400 to 56 100 kp)
Maximum pulling power - Haulback	10 to 60 kN (1 000 to 6 100 kp)	100 to 240 kN (10 200 to 24 500 kp)	110 to 880 kN (11 200 to 89 700 kp)	70 to 530 kN (7 100 to 54 000 kp)
Maximum line speed - Skyline	0.5 to 5.0 m/s	4.0 to 10.0 m/s	4.0 to 10.0 m/s	-
Maximum line speed - Mainline	3.5 to 8.0 m/s	4.0 to 16.0 m/s	4.0 to 13.0 m/s	4.0 to 15.0 m/s
Maximum line speed - Haulback	4.5 to 8.0 m/s	5.0 to 16.0 m/s	9.0 to 30.0 m/s	4.0 to 16.0 m/s
Maximum drum capacity - Skyline	300 to 800 m	200 to 1 500 m	500 to 900 m	-
Maximum drum capacity - Mainline	300 to 1 200 m	150 to 1 300 m	300 to 900 m	450 to 850 m
Maximum drum capacity - Haulback	600 to 1 600 m	350 to 1 300 m	900 to 1 800 m	700 to 1 500 m
Tower height	4.5 to 10.0 m	7.5 to 20.0 m	15.0 to 37.0 m	13.5 to 19.0 m
Engine power	19 to 186 kW (25 to 250 hp)	45 to 261 kW (60 to 350 hp)	224 to 485 kW (300 to 650 hp)	142 to 343 kW (190 to 460 hp)
Weight (tower, yarder & carrier)	2 000 to 20 000 kg	14 000 to 50 000 kg	30 000 to 120 000 kg	40 000 to 90 000 kg

3. CARRIAGES AND ACCESSORIES

Carriages are available in many different designs. Carriage design must be compatible with the harvesting conditions and requirements and with the cable logging system which will be used. These design features are important in the classification of carriages in accordance with the types of application for which the carriage can be used.

Some important factors which determine the type of application for a carriage are:

- whether or not the carriage can pass over intermediate skyline supports
- whether the carriage is held in position on the skyline with a carriage stop, carriage clamp or operating lines
- whether or not the carriage is dependent upon gravity to carry it in one direction along the skyline
- whether or not the carriage has skidding capabilities
- the cable logging systems with which the carriage can be used.

Since most carriages have a combination of operating features and the same carriage can often be used in different ways, modified for different applications and used with different cable logging systems, it is impossible to classify each carriage into a single category.

The major carriage features and some modification possibilities are described below.

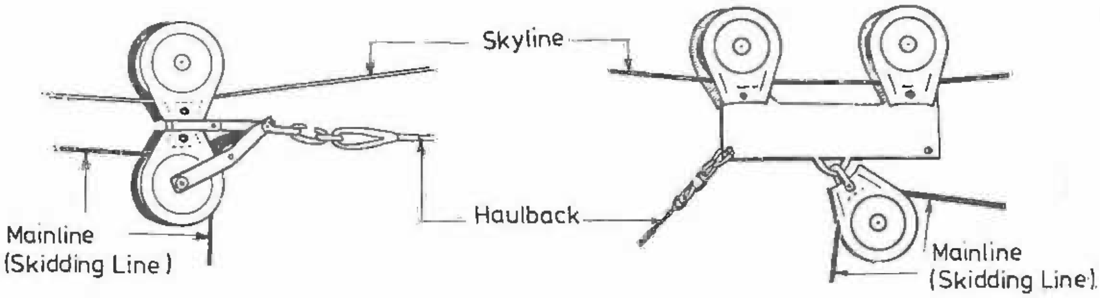
3.1 Single-Span Skyline Carriage

Such carriages cannot pass over intermediate skyline supports and therefore are limited to single span usage. See the examples in Figures 37 (below), 44, 45, 46 and 47 on Pages 53, 54 and 56 respectively.

It should be noted that some of these carriages can be modified for multispan skyline usage.

Figure 37 - Single Span Carriage

Held in position with operating lines, Non-gravity, Skidding Capability. (Normally used with double drum Machine-mounted Winches and Small Mobile Tower Yarders)



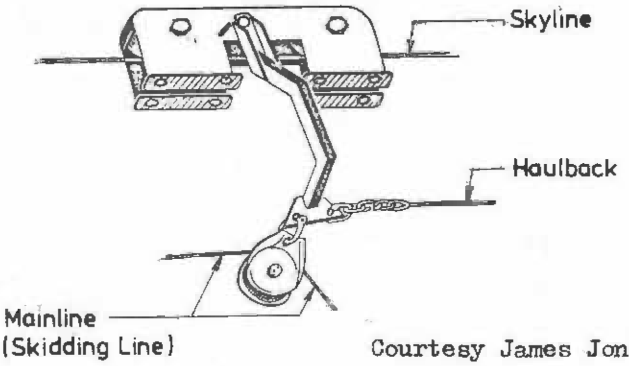
Courtesy James Jones & Sons Limited

3.2 Multispan Skyline Carriage

Such carriages are designed to pass over intermediate skyline supports and therefore can be used on multispan skylines. See the examples in Figures 38, 39, 40, 41 and 42.

Figure 38 - Multispan Carriage

Held in position with operating lines, Non-gravity, Skidding Capability, (Normally used with Small Mobile Tower Yarders)



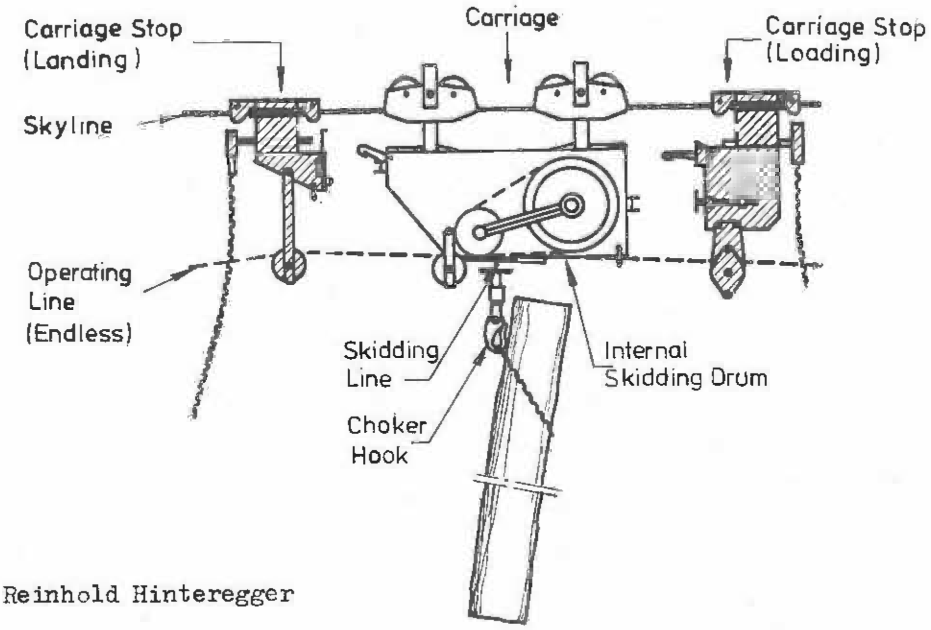
Courtesy James Jones & Sons Ltd

3.3 Carriage Stops

Carriage stops are one means of holding the carriage in position on the skyline. An example of a carriage used with carriage stops is shown in Figure 39. Carriage stops can be moved to any location along the skyline and locked in place by a man on the ground. When the carriage comes into contact with the carriage stop it is automatically locked in place. The choker hook can then be lowered by letting the operating line feed through the carriage (gravity system) or by feeding out the skidding line from an internal skidding drum (non-gravity system). When the turn of the logs is brought into the carriage, the carriage is automatically released.

Figure 39 - Carriage Stops

Multispan carriage, held in position with carriage stops, Non-gravity, Skidding Capability (Normally used with Yarders and Small Mobile Tower Yarders)



Courtesy Reinhold Hinteregger

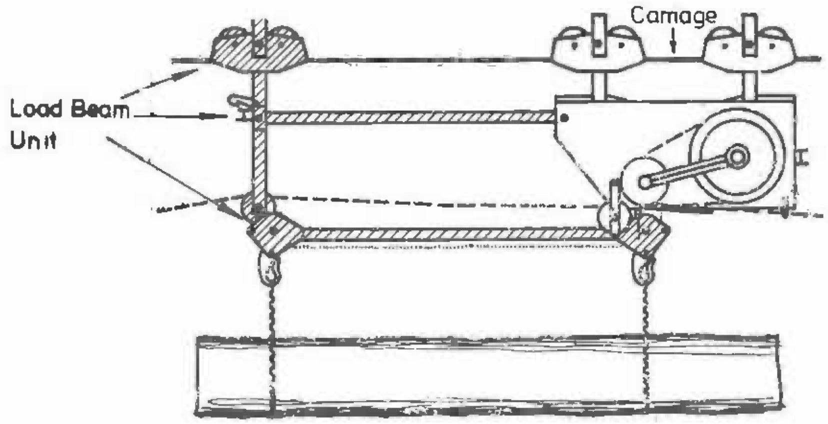
3.4 Load Beam

Such units (Figure 40) consist of a set of blocks and bars which are attached to carriages of the type shown in Figures 39 and 41.

Load beams increase the load capacity of the carriage by 50 percent and allow the load to be transported horizontally.

Figure 40 - Load Beam

Multispan Carriages, held in position with Carriage Stops or Clamps, Non-gravity or Gravity, Limited Skidding Capability (Normally used with Yarders)



Courtesy Reinhold Hinteregger

3.5 Clamping Carriage

Such carriages employ one or more carriage mounted clamps to hold the carriage in position on the skyline. The clamps are activated by a timer, by radio or manually when the carriage is stopped. The skidding line is fed out in the manner described above under Carriage Stop. When the turn of logs is brought up to the carriage the clamp is released automatically or by radio.

Examples of the most common types of clamping carriages used with yarders are shown in Figure 41. These carriages employ one clamp. Another clamping carriage construction, which is used with yarders, is shown in Figure 42. This type of carriage uses two clamps: one on the skyline and one on the haulback line.

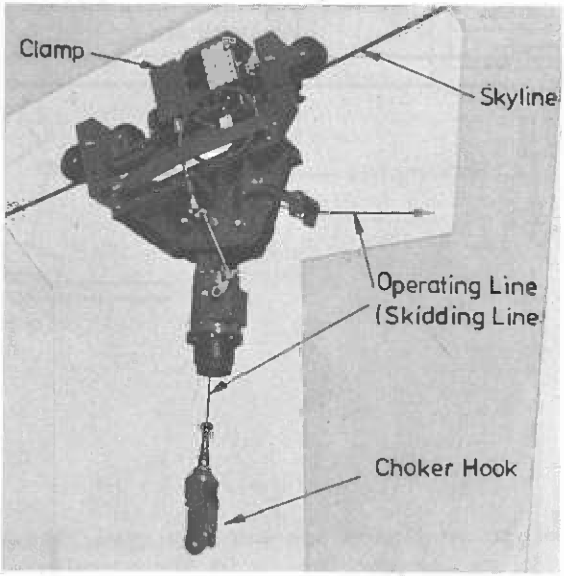
The mainline, haulback line and skidding line are connected at a squirrel carriage which runs on the skyline. The lines can also be connected with a three-way swivel. The clamps function in such a manner that when the skyline clamp is open, the haulback clamp is closed. In this situation the carriage can be moved on the skyline by moving the operating line. When the carriage is positioned and the skyline clamp is closed, the haulback clamp is opened and the skidding line can be let out and pulled in by moving the operating lines.

Clamping carriages such as the one shown in Figure 45 on Page 54 return to the operating area by gravity, are positioned in the skyline with the mainline, the clamp is activated manually or by radio and the skidding line can then be pulled out. The type of carriage shown in Figure 46 on Page 54 is operated in the same manner as the carriage in Figure 45, with the exception of the skidding line which is operated by a radio-controlled motor in the carriage.

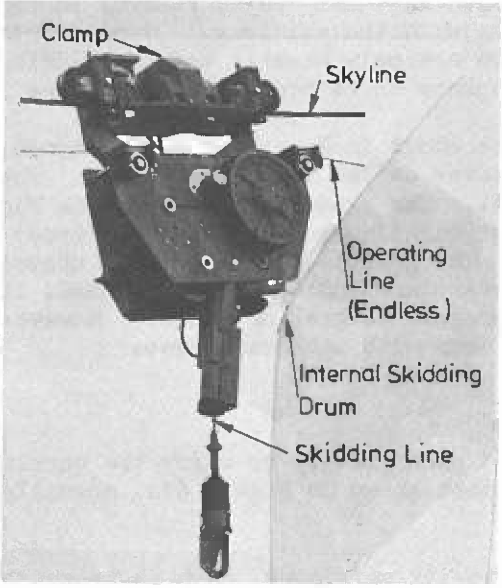
Figure 41 - Clamping Carriages, Single Clamp Design

Multispan Carriages, held in position with Carriage Clamp, Skidding Capability
(Normally used with Yarders and Small Mobile Tower Yarders)

a. Gravity with Load



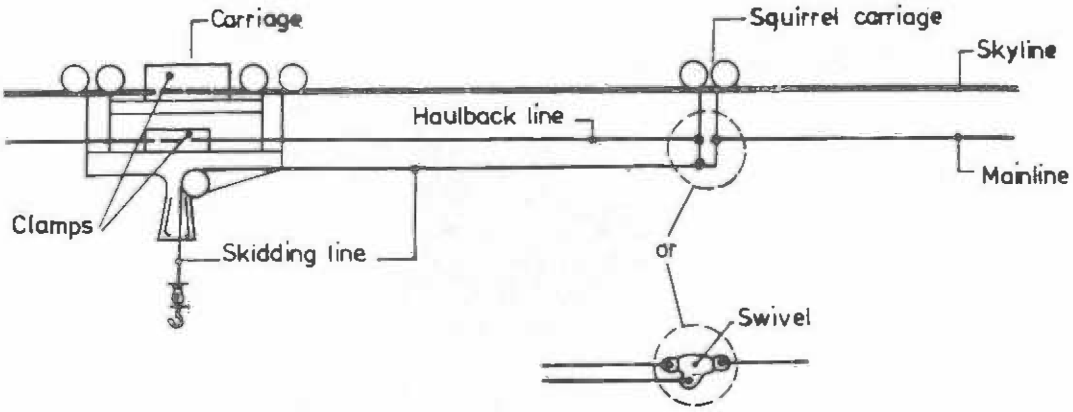
b. Non-gravity



Courtesy BACO Seilbahnen

Figure 42 - Clamping Carriage - Two-Clamp Design

Multispan Carriage, held in position with Carriage Clamp, Non-gravity, Skidding Capability (Normally used with Yarders and Small Mobile Tower Yarders)



3.6 Operating Lines

When carriage stops or clamps are not employed, the operating lines are used to hold the carriage in position on the skyline. In the examples shown in Figures 37 and 38, the carriage is returned to the operating area with the haulback line and is positioned along the skyline with the mainline and haulback line. In these examples the mainline also serves as the skidding line.

The type of carriage shown in Figure 44 returns to the operating area by gravity and is positioned on the skyline with the mainline. Some carriages of this design also have a skyline clamp. Since there are only chokers and no skidding line, the skyline must be lowered in order for the chokers to be connected around the logs.

Carriages of the type shown in Figure 47 are returned to the operating area with the haulback line which also serves as the running skyline. The carriage is positioned with the mainlines and haulback line. The skidding line shown in Figure 47a (on Page 56), is operated with the mainlines (mainline and slackpulling line) as is the grapple line in Figure 47b (on Page 56). The grapple line opens and closes the grapples. Since the grapple is attached to the carriage and cannot be lowered, it is necessary to lower the carriage in order for the grapple to grab any logs. However, the skidding line can usually be extended out to 40 m or more with such carriages.

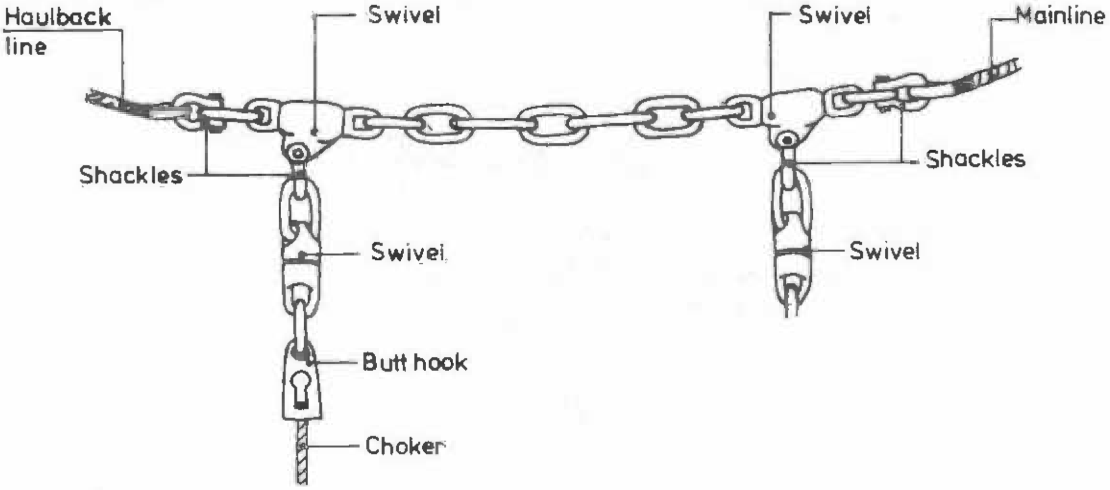
3.7 Gravity Carriage

Such carriages depend upon gravity to carry the carriage down the skyline. European gravity carriages, such as that shown in Figure 41a, normally use gravity to transport the carriage when loaded.

The North American gravity carriages, such as those shown in Figures 44, 45 and 46 on Pages 53 and 54 normally use gravity to transport the carriage without a load.

Figure 43 - Highlead Butt Rigging - Two-Choker Design

Single-span from Tower to Tailblock, Non-gravity, Held in position with Operating Lines; No Skidding Capability (Normally used with Medium and Large Mobile Tower Yarders)



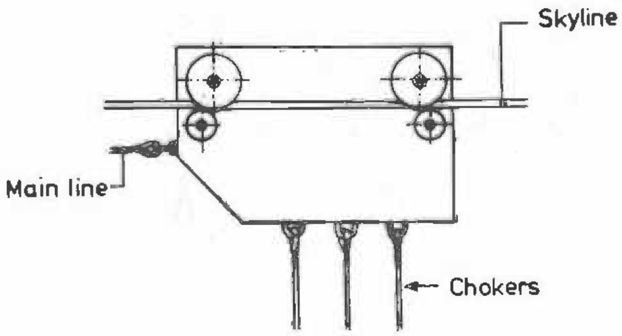
3.8 Non-gravity Carriage

Such carriages use operating lines to move the carriage in either direction along the skyline. The term "all-terrain" is used in the European Alps to describe cable cranes which do not depend upon gravity for transporting the loaded carriage. The carriages for these systems (Figures 39, 40, 41b and 42) are designed for uphill or downhill yarding as well as for use over flat terrain.

The carriages shown in Figures 37, 38 and 39 can be used for uphill and downhill operations. If a haulback line is attached in addition to the mainline, carriages of the types shown in Figures 44, 45 and 46 can also be used for uphill and downhill operations.

Figure 44 - Single-Span Carriage, No Skidding Capability

Held in position with operating lines, Gravity without Load (Normally used with Medium and Large Mobile Tower Yarders)

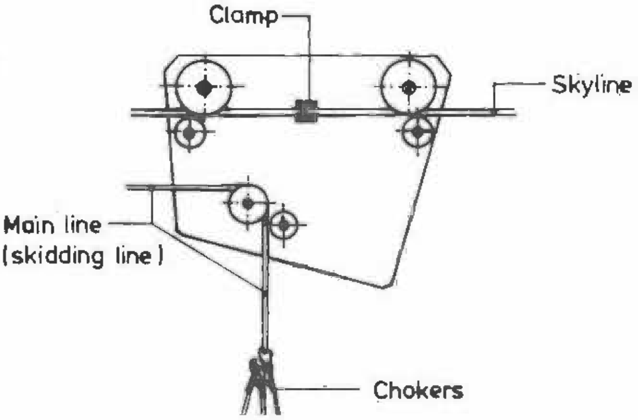


3.9 Butt Rigging

This is not a carriage but is actually a set of swivels and chain which is used to connect the mainline and haulback line together (Figure 43). Chokers are fastened to the butt rigging. The butt rigging is returned to the operating area with the haulback line and is positioned with the mainline and haulback line. Since there is no skidding line, the butt rigging must be lowered in order for the chokers to be connected around the logs.

Figure 45 - Single Span Carriage, Skidding Capability

Held in position with Carriage Clamp, Gravity without Load (Normally used with Medium and Large Mobile Tower Yarders)

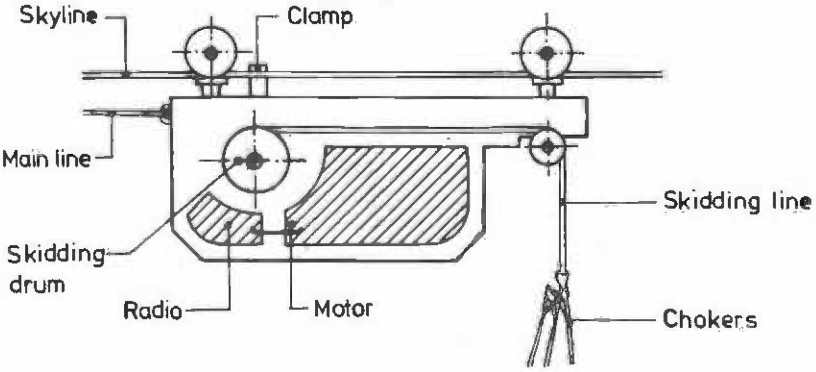


3.10 Skidding Capability

With a carriage which has skidding (later yarding) capability it is possible for a skidding line to be extended out from and pulled into the carriage. The skidding line is usually either an operating line which is pulled through the carriage (Figures 37, 38, on Pages 48 and 49; Figure 41a, Page 51; and Figure 45, above); a separate skidding line which is pulled through the carriage (Figures 42 and 47a); or a separate skidding line which is contained on a carriage-mounted skidding drum (Figure 39 on Page 49; Figure 41b, Page 51; and Figure 46, below).

Figure 46 - Single-Span or Multispan Carriage, Radio-Controlled

Held in position with Carriage Clamp, Gravity without Load or Non-gravity, Skidding Capability (Normally used with Medium or Large Mobile Tower Yarders)



A carriage which can be used for skidding is often called a "slackpulling carriage" in North America.

Carriages that have skidding capability can be used in thinning and partial cutting operations as well as clearcut operations. Carriages which do not have skidding capability (Figures 44 and 47b, and the butt rigging shown in Figure 43) are designed for clearcut operations. The use of non-skidding carriages for thinning and partial cut operations usually results in unnecessary damage to the remaining trees as well as a greater number of yarding strips when compared to the use of skidding carriages in the same situation.

The general specifications for carriages are given in Table 11 on Page 57, and some selected examples are given in Appendix 1.

3.11 Carriage and Cable Logging System Combinations

The possible carriage and cable logging system combinations are numerous and appear to be infinite in number. Each of the captions for Figures 37 through 47 includes a comment regarding the cable logging system(s) with which the illustrated type of carriage is normally used. These are usually the systems for which the carriages were originally designed. This does not, however, mean that usage is limited to the systems mentioned.

The types of carriages shown in Figures 37 through 42 are commonly used in Europe. The butt rigging shown in Figure 43 and the types of carriages shown in Figures 44 through 47 are commonly used in North America.

The important carriage features and the cable logging system(s) with which these features are most commonly employed are shown in Table 12.

3.12 Skyline Load Capacity

An aspect of carriage design that has an important influence upon the load capacity of a live or standing skyline is whether the carriage is unclamped or clamped to the skyline. Except for a chord slope of 0 percent the load carrying capability of a skyline with a clamped carriage will be less than for an unclamped carriage. This difference in load capability can take on important proportions. With a very steep slope and a large deflection (refer to Figure 48), e.g. 80 percent chord slope and 15 percent midspan deflection, an unclamped carriage can have an allowable payload that is more than 30 percent greater than for a clamped carriage. This is due to the assistance that the skyline receives from the mainline when the mainline helps support the load. The difference in load carrying capability is valid only for the time during which the carriage is clamped.

For the purpose of describing the effect upon skyline load capacity, carriages can be divided into the two following categories:

a) Clamped carriages

This includes all clamped carriages (carriage stops have the same function as a clamp) which do not have an active mainline pulling towards the upper end of the skyline. In other words, the mainline is assumed to be slack or pulling toward the lower end of the skyline.

b) Unclamped carriages

This includes not only unclamped carriages, but also clamped carriages with an active mainline pulling toward the upper end of the skyline.

Table 12 – Carriage and Cable Logging System Combinations Commonly Used Together

Carriage Features	Cable Logging Systems						
	Machine-mounted Winches	Yarders		Mobile Tower Yarders			Running Skyline Swing Yarders
		Single	Multispan	Small	Medium	Large	
Single-Span Design	X	X		X	X	X	X
Multi-Span Design			X	X	X	X	
Carriage Stop Control		X	X	X			
Carriage Clamp Control		X	X	X	X	X	
Operating Line Control	X	X		X	X	X	X
Gravity with Load		X	X				
Gravity without Load		X			X	X	
Non-gravity	X	X	X	X	X	X	X
Load Beam Attachment		X	X				
Skidding Capability	X	X	X	X	X	X	X
No Skidding Capability		X			X	X	X
Butt Rigging		X			X	X	

4. PRODUCTIVITY

4.1 Factors which affect Productivity

The productivity of cable logging systems is highly diverse due to the great variability in the natural and the developed (man-made) conditions to be found in forests and forest areas.

Generally, each harvesting plan is determined by the prevailing natural forest conditions and the silvicultural regime to be practiced, taking into consideration environmental factors. Natural and developed conditions will affect each other at the primary stage of harvesting planning.

It is logical to assume that there are certain stands that can best be harvested with tractors, whereas others, in more difficult terrain, can best be harvested by cables. In other words, more than one system may be applicable for a set of natural conditions. It is often a question of creating the right set of developed conditions to meet those in existing forests.

If the wrong set of developed conditions is adopted for use in natural forests, productivity will never reach its potential level. Similarly, a cable logging system may be employed in a set of both existing natural and developed conditions, even though, if the situation was thoroughly analyzed, it would be advantageous to change the developed conditions. A change in developed conditions can improve the productivity of the system employed, or can allow for the introduction of a system more suited to the modified conditions.

Although productivity is an important consideration when selecting a cable logging system, the final choice must be based primarily upon the economics of the forest operations after having considered the environmental impact of the proposed system. It could be that, even though the productivity of a cable logging system reaches acceptable levels, it still may not be the most appropriate or the most economical one for use in natural forest. Because of the great number of variabilities which exist in forest areas, each case must be judged entirely on its own merits.

Important natural variables are:

- Weight, size and form of trees and logs
- Distribution, size and location of forest stands
- Size class distribution of trees and logs within a stand
- Volume per ha
- Topography
- Length of slopes
- Density of obstacles and vegetation
- Climate

Important developed variables are:

- Road location, standards and spacing
- Terrain transportation distance (a function of road spacing)
- Lift and deflection
- Cutting, limbing, bucking, decking, loading and hauling conditions
- Capability, experience and organization of personnel
- Type of harvest, i.e. silvicultural treatment: clearcut, partial cut, thinning etc.

The above variables not only influence productivity but are also instrumental in determining which cable logging system should be selected for harvesting a forest resource. Only after an appropriate system (or systems) has been selected, with consideration to the above variables, is it possible to forecast the levels of productivity which can be expected under the existing natural conditions and under the conditions to be created in the development of the forest.

4.2 Mechanical Specifications

According to the natural and developed conditions, an appropriate cable logging system (or systems) would be selected. Each system generally consists of a power supply, wire rope, carriage and other accessories. One or more machines should be selected from amongst the available ones.

Each machine has both mechanical and/or economical advantages and disadvantages. Therefore, the mechanical specifications of each machine are important as factors which must correspond to the natural and developed conditions.

Important mechanical specifications are:

- Maximum pulling power of each operating line
- Maximum line speed of each operating line
- Maximum drum capacity of each operating line
- Engine power (or engine power required)
- Number and type of drums (including options)
- Tower height
- Weight (of complete unit)

4.3 Available Productivity Data

A great deal has been written about the productivity of cable logging operations. Unfortunately, only a very small portion of the available information contains enough of the important background data which is necessary to make meaningful comparisons with other cable logging operations. When the important variables are not known, comparisons can be misleading, and can lead to incorrect conclusions and thus increased costs, especially when the cable logging system chosen is not the most appropriate for the existing forest conditions.

The only productivity data presented in this report is that which has been derived from studies and analysis of cable logging operations conducted in different parts of the world. This is only a small portion of the productivity data which has been published throughout the world. Even though there is much more available, very little of it meets the data criteria established for this report. These criteria are:

- The data must be based upon field measurements
- As many measurements as possible must be taken, over a sufficient period of time, in order to arrive at tolerable average results, i.e. the data presented must be for average production results, not exceptional production results
- Data must be given on the variables listed below:
  - Volume per ha
  - Number of pieces per ha
  - Volume per piece
  - Harvesting system (full-tree, tree-length or shortwood)
  - Type of cut (clearcut, partial cut, thinning, etc.)
  - Uphill or downhill
  - Average yarding distance in mainline and lateral

- Useful data on the variables would be:
  - Area
  - Topography
  - Density of obstacles and vegetation
  - Weather and temperature

- Indispensable mechanical and operational data must be:
  - Maximum pulling power of the mainline
  - Type of cable configuration

- Useful mechanical and operational data would be:
  - Capability, experience and organization of personnel

Data should be presented as shown below, or in such a manner that it can be converted into this form for comparative purposes:

- Volume in solid cubic metres
- Productivity per 8-hour shift
- Number of yarding cycles/turns per 8-hour shift
- Moving, set-up and take-down times

The data presented in Table 13 gives the average productivity in cubic metres (solid) per 8-hour shift, segregated within each category of cable logging system according to the maximum pulling power of the mainline.

It is important to note that over shorter periods of time, for example one day, there can and will be great deviations from average productivity. There are exceptional operating days in which production can be much more or less than the average productivity. Such exceptional days cannot be used as a guide to the productivity that should be expected from a cable logging system.

4.4 Productivity of Different Cable Logging Operations

Productivity will vary greatly from region to region and from logging unit to logging unit. The information presented here gives a fairly representative picture of the variations which occur in average production. The reasons for these variations are many and can be better understood by examining the data given for each example in Table 13 (on Page 68). Figure 49, given at the end of Table 13, shows productivity related to pulling power for all the cable logging system examples given in Table 13. It should be noted that the average maximum yarding distance has been rounded to the nearest 5 m and productivity has been rounded to the nearest 5 m^3 in Table 13.

Variability in productivity is described, by cable logging system, in the following sections:

4.4.1 Independent Bunching Winches

The productivity of independent bunching winches varies primarily with:

- Pulling power
- Yarding distance
- Terrain conditions (i.e. boulders)
- Piece size
- Volume per ha

These winches are usually used in ground lead and are mainly designed for use in thinnings where the logs may be quite small. In forest stands with larger tree and log sizes, bunching is of less importance.

Productivity can also be improved by hanging the blocks at a height that will give some lift to the leading end of the turn.

The maximum yarding distance is quite short - usually between 10 and 50 m.

Table 13 presents data from some operations in which the productivity of independent bunching winches was measured.

Table 13 indicates that the correlation between mainline pulling power and productivity is relatively consistent, which indicates that the winches in these examples are rather well suited to the conditions in which they were used, and were employed in a relatively efficient manner. For example, in the 8 kN class the small volume per piece and per turn in one operation was compensated for by increasing the number of turns. This indicates that the ability to yard faster with a smaller turn was utilized.

Whether the machines are radio-controlled or not is not directly related to the productivity. In other words, the volume per turn is not affected by the number of operators. Costs due to the machine prices (depreciation), wages, or other costs would decide which type is better in each case. Radio-controlled machines are usually more expensive.

4.4.2 Machine-Mounted Winches

Machine-mounted winches are unique among the cable logging systems in that, other than for some special exceptions, their productivity is directly related to the capacity and travel speed of the base machine upon which the winch is mounted. This is due to the fact that the terrain transportation is done primarily with the machine, and the winch is normally only use for short distance movement of logs. Consequently, pulling power and productivity are not directly related for machine-mounted winches.

4.4.3 Yarders

The productivity of yarders varies primarily with:

- Pulling power
- Line speed
- Mainline load capacity (for non-skyline configurations)
- Skyline load capacity (for skyline configurations)
- Yarding distance (for highlead; skyline length and lateral skidding distance)
- Piece size
- Volume per ha
- Number of pieces per ha
- Type of harvest (clearcut etc.)
- Harvesting system (full-tree etc.)
- Cable configuration

In a skyline configuration, an increase in line speed will increase productivity; however, this generally requires an increase in engine power. In highlead or other cable configurations in which logs are dragged along the ground, line speed may have less effect on productivity than in the skyline configuration, since ground obstacles might prevent smooth yarding. Therefore in highlead, pulling power is more important than line speed since it is necessary to pull more load at slower speeds. In other words, the productivity in a skyline configuration will be due to both the pulling power and the line speed; the former affects the size of the turn and the latter affects the number of turns; however, productivity in the highlead system will be mostly due to pulling power since the line speed will be slow and the number of turns will be more or less constant.

An increase in load capacity will allow an increase in load size, but the number of turns per productive hour may decrease since the time required to assemble an adequate load may increase. Log size and weight are an important function of productivity along with pre-treatment such as topping, limbing and bucking (i.e. harvesting system).

As yarding distance increases, productivity per shift decreases. However, as the yarding distance increases and the productivity decreases, the number of hours available for production will increase, since less time is spent on setting-up. In normal cases, higher productivity is obtained from shorter yarding; however, overall costs may not be reduced if additional road costs are taken into account.

Generally speaking skyline configurations are used for longer yarding distances rather than highlead. Optimal yarding distances are in the order of 200 to 250 m in highlead and 400 to 600 m in skyline configurations. A cable configuration which is suitable for the yarding distance should be selected.

As lateral yarding distance increases, productivity will decrease, and this will be even greater when the lateral yarding (skidding) is done in thinnings or partial cuts. One advantage of lateral yarding is that it increases the effective width of each road with a resultant decrease in the number of roads which are required to harvest an area. This means that a smaller proportion of the time will be spent for moving.

However, longer lateral distances generally require a more complex cable configuration which therefore consumes more time in installation and removing. With simple cable configurations, for instance highlead, longer lateral distances will lower productivity, due to the likelihood of more hang-ups; therefore the advantage of wider roads will be diminished because of the short setting-up and taking-down time of the system.

The higher the skyline or mainline, the easier the lateral yarding, because of the added lift.

When log size is small, more time will be required to collect the logs required for an adequate load. The same thing is true when the volume per ha is low. In such cases, if the logs to be harvested are not pre-bunched, it will be necessary to collect the logs with the cable logging system in order to get large enough loads. If logs are not pre-bunched, either loads will be undersized or too much time will be spent assembling an adequate one. In either case productivity will decrease.

In such situations productivity can be improved by complementing the system with the use of independent bunching winches. This is especially applicable in situations where the log size is smaller and the volume per ha is lower than is desirable for the equipment being used.

In thinning and partial cut operations productivity is lower than for clearcuts since lateral yarding is slow, due to the need to negotiate the logs between the standing trees. In addition, the volume per ha removed in thinnings and partial cuts is less than the volumes removed in clearcuts.

Maximum yarder yarding distances vary from 300 to 1 500 m depending upon drum capacity, type of yarder, and cable configuration.

Table 13 presents data from some operations in which the productivity of yarders was measured.

4.4.4 Yarding Trailers for Continuous Mainline Systems

The productivity of yarding trailers for continuous mainline systems varies primarily with:

- Yarding distance
- Terrain
- Piece size
- Volume per ha removed
- Number of pieces per ha

This system is designed for use in thinning operations. At present there is only one commercial manufacturer which produces only one model of this system.

When the tree size and volume per ha removed remain fairly constant, and the system is operated at the recommended maximum yarding distance of 250 to 350 m, productivity will not show much variation. When the yarding distance is short or the volume per ha removed is low, a large proportion of the time will be spent in moving the system and productivity will decrease.

Table 13 presents data from some operations in which the productivity of yarding trailers continuous mainline system was measured (see Page 68).

Productivity is strongly influenced by the volume per piece since this is usually the same as volume per turn.

4.4.5 Small Mobile Tower Yarders

The productivity for small mobile tower yarders varies primarily with:

- Pulling power
- Line speed
- Mainline or skyline/carriage load capacity
- Yarding distance (skyline and lateral)
- Piece size
- Volume per ha
- Number of pieces per ha
- Type of harvest
- Harvesting system
- Cable configuration

Since small mobile tower yarders are designed for the same type of single and multi-span skyline yarding as yarders, productivity varies in the same manner as is described in the section for yarders. The main difference between these two systems is that a small mobile tower yarder is mounted on a carrier with a tower for quick setting-up and taking-down times and is normally used for shorter yarding distances.

Table 13 (on Page 68) presents data from some operations in which the productivity of small mobile tower yarders was measured.

An examination of the data in Table 13 reveals the fact that the correlation between mainline pulling power and productivity for these different operations is not very consistent. This indicates that other factors or conditions have had an important influence upon productivity. This also indicates that the capabilities of these systems are not always well matched to the forest conditions or that these capabilities are not fully utilized.

The apparent good utilization of the system capabilities in the 15 kN class is greatly influenced by the short yarding distance.

The two operations in the 49 kN class which produced 20 m^3 in an 8-hour shift were influenced by the relatively long yarding distances. The productivity would be higher with a shorter yarding distance. The operation in the same class which produced 55 m^3 was greatly influenced by the fact that a clearcut was made within a relatively short yarding distance from the machine.

Except for the operations which have been commented upon, productivity is relatively consistent for the operations presented here.

4.4.6 Medium Mobile Tower Yarders

The productivity of medium mobile tower yarders varies primarily with:

- Pulling power
- Line speed
- Load capacity
- Yarding distance
- Piece size
- Volume per ha
- Number of pieces per ha
- Type of harvest
- Harvesting system
- Cable configuration

When using a skyline configuration, line speed will affect productivity. When using a highlead (non-skyline) configuration, line speed will have less effect on productivity than with skylines since the turns of logs will often encounter obstacles on the ground which will slow or even stop the yarding process. In addition, logs which are being dragged on the ground can break if they are dragged too fast. To avoid damaging the equipment and the logs it is necessary to pull the load at a reasonably slow speed. Consequently, with the highlead configuration, where pulling power is more important than line speed, the turn will usually be pulled at a speed which is far below the capability of the yarder.

Pulling power is a key factor with a highlead configuration, since to counteract the slow speeds mentioned above, it is necessary to pull as large a load as possible. The larger and heavier the load, the greater the likelihood that the load will encounter obstacles on the ground. Therefore it is important that the pulling power is great enough to pull the load through or over obstacles. For skyline configurations the load capacity of the skyline and carriage are important.

Yarding distance has the same basic effect upon skyline configurations as is described under yarders. However, in clearcutting operations side blocking is sometimes used to increase the effective width of the yarding road. This can be used in highlead as well as live skyline operations. Increased yarding distance has an additional negative effect upon a highlead configuration in that lift is reduced and the loads will encounter more obstacles. This is the main reason why highlead yarding distance does not normally exceed 300 m.

Log size and volume per ha have the same effect upon productivity as is described under yarders.

Table 13 presents data from some operations in which the productivity of medium mobile tower yarders was measured (see Page 68).

Table 13 shows that the correlation between mainline pulling power and productivity for these different operations is not very consistent. One key factor is that although a powerful yarder is needed to handle large and heavy pieces, this capability is not always needed and therefore cannot always be utilized. Consequently the yarder is, and must be, overpowered for its average use. Another key factor is that there is more than one type of cable configuration employed in the examples given here. Since there are (as explained above) different factors that affect the productivity of these different configurations, it is to be expected that productivity will be different.

The figures for the highlead configurations given in Table 13 show much lower levels of productivity than the various skyline configurations. As described above, one main reason is because skyline systems operate at faster line speeds. A compensating factor is that the setting-up and taking-down time is normally greater for a skyline system than for a highlead system. Moving in, setting-up and taking-down times are not included in the productivity data for medium mobile tower yarders.

The volume per turn in these skyline operations was usually considerably larger than for the highlead operations. This, together with the travel speed of the turn, resulted in much higher productivity for the skyline configurations, even when yarding distance was considerably greater than for the operations which used a highlead configuration.

It is of interest to note that the maximum yarding distances used in the operations shown here are considerably less than the capabilities of the yarders.

4.4.7 Large Mobile Tower Yarders

The productivity of large mobile tower yarders varies primarily with the same factors as for medium mobile tower yarders. These variables affect the productivity of large mobile tower yarders in the same way as they affect medium mobile tower yarders. This is explained in the previous section on medium mobile tower yarders.

Table 13 on Page 68, presents data from some operations in which the productivity of large mobile tower yarders was measured.

The correlation between mainline pulling power and productivity for these different operations is similar to the correlation for medium mobile tower yarders. This is to be expected since these two categories have the same operating characteristics.

The 377 kN yarders were employed in operations where mahogany was selectively logged from the forest. The volume per ha removed in these operations is considerably less than in the other large mobile tower yarder operations. The yarding distances are also much longer than for the other highlead operations. These two operations used wooden spars.

The 364 kN operation is interesting in that the productivity was high even though the maximum yarding distance was greater than the other operations. This operation employed a gravity line system which, with the high speed with which the carriage can return to the operating area, compensates for the relatively long yarding distance. Additionally, the large volume per turn is clearly an important factor in achieving this high level of productivity.

4.4.8 Running Skyline Swing Yarders

The productivity of running skyline swing yarders varies primarily with:

- Pulling power
- Line speed
- Load capacity
- Yarding distance

- Deflection
- Piece size
- Volume per ha

These variables affect the productivity of running skyline swing yarders in the same way as they affect medium mobile tower yarders and large mobile tower yarders. In addition, log size can have a dramatic impact upon productivity when a grapple carriage is being used. This is due to the fact that, when a grapple is used, each turn will usually consist of only one log.

Adequate deflection is important in order that the turn of logs being yarded into the landing are not slowed down. If the carriage or logs come into contact with the ground or obstacles on the ground, the line speed must be reduced with a direct negative effect upon production. Deflection is especially important when using a grapple carriage. Without proper deflection the grapple cannot be positioned over the logs.

Table 13 presents data from some operations in which the productivity of running skyline swing yarders was measured.

In Table 13 (Page 68), the correlation between mainline pulling power and productivity for these different operations is relatively consistent, with the exception of the 428 kN yarder which produced only 140 m^3 per 8 hour shift. Even so, the increase in productivity is not proportionate to the increase in the pulling power. The capabilities of the more powerful yarders cannot always be utilized with the result that they are quite often less productive than could be expected. This situation is somewhat evident in the volume per piece for these running skyling swing yarder operations.

The 249 kN yarder with a productivity of 155 m^3 is interesting in that productivity was good even though it was operating in a partial cut with a relatively long yarding distance (as compared to the other 249 kN yarder). The ability to average two logs per turn when using chokers is advantageous as compared to an average of a little more than one log per turn for the grapple operation.

The two 428 kN yarders were operated on the basis of two shifts per day with the result that approximately half of their operating time was at night. The yarder with the 140 m^3 productivity had, in addition to the smaller volume per piece, a relatively large amount of mechanical problems.

The maximum yarding distances for the running skyline swing yarder operations shown here are, as is also common for most of the other cable logging systems, considerably less than the capabilities of these yarders.

Figure 49 (on Page 72), gives a comparison of productivity related to pulling power for each of the operations shown in Table 13.

Table 13 - Comparison of Productivity Data

Mainline Pulling Power KN	Average Yarding Mainline m	Maximum Distance Lateral m	Volume/ Total m^3	Hectare Removed m^3	Volume/ Piece m^3	Turns/ Shift	Volume/ Turn m^3	Productivity/ 8 Hour Shift m^3	Location	Notes
INDEPENDENT BUNCHING WINCHES										I
8	50	-	270	58	0.20	45	0.38	15	Scandinavia	T
	50	-	130	36	0.14	55	0.29	15	"	T
15	50	-	-	-	-	70	0.30	20	"	T
40	25	-	495	178	0.45	79	0.59	45	North America West Coast	T
YARDERS										N
20	700	-	-	-	-	39	1.3	50	European Alps	CD
	700	-	-	-	-	49	1.2	60	"	CD
	300	-	-	-	-	45	0.9	40	"	CU
39	1000	-	-	-	0.18	-	-	20	Scandinavia	CDCu
	900	-	-	-	0.36	31	1.3	45	"	CDCu
	1200	50	-	200	0.60	16	1.8	30	Asia	PD
49	900	15	-	-	-	33	1.5	50	European Alps	CD
80	1200	75	233	233	1.34	21	4.0	85	North America West Coast	CD
YARDING TRAILERS FOR CONTINUOUS MAINLINE SYSTEM										I
59	300	-	-	-	0.2	150	0.2	30	European Alps	TU
	250	-	-	-	0.05	320	0.05	15	"	TU

TABLE 13: Cont'd

Mainline Pulling Power	Average Maximum Yarding Distance Mainline	Average Maximum Yarding Distance Lateral	Volume/Hectare Total	Volume/Hectare Removed	Volume/ Piece	Turns/ Shift	Volume/ Turn	Productivity/ 8 Hour Shift	Location	Notes
KN	m	m	m^3	m^3	m^3		m^3	m^3		
SMALL MOBILE TOWER YARDERS										N
15	80	15	97	97	-	102	0.5	45	European Alps	CU
	165	20	181	181	-	89	0.9	80	"	CU
	205	15	273	273	-	66	0.7	45	"	CU
21	280	-	320	30	0.80	37	1.3	50	"	TU
39	300	15	-	-	-	-	0.5	30	United Kingdom	TUD
49	555	-	510	510	0.62	19	1.0	20	Scandinavia	CUD
	530	-	209	209	0.55	9	2.1	20	"	CUD
	240	30	-	-	0.43	-	-	55	North America West Coast	CTU
	300	-	-	-	0.55	-	-	40	"	TU
	300	25	150	-	-	38	1.0	40	Central America	D
	300	20	503	503	1.27	24	1.7	40	European Alps	CU
MEDIUM MOBILE TOWER YARDERS										N
111	115	-	238	238	0.62	68	1.2	100	North America West Interior	CUH
152	220	40	-	-	1.9	52	3.1	160	European Alps	CUL
251	85	-	252	252	0.79	45	1.9	85	North America West Interior	CUH
	125	-	210	210	0.86	35	2.5	100	"	CUH
276	260	-	490-1050	490-1050	1.2	105	2.6	280	North America West Coast	CUR
299	160	-	490-1050	490-1050	0.7	88	1.6	145	"	CUH
	120	-	490-1050	490-1050	1.4	90	2.8	265	"	CUS

TABLE 13: Cont'd

Mainline Pulling Power	Average Maximum Yarding Distance Mainline	Average Maximum Yarding Distance Lateral	Volume/Hectare Total	Volume/Hectare Removed	Volume/Piece	Turns/Shift	Volume/Turn	Productivity/8 Hour Shift	Location	Notes
KN	m	m	m^3	m^3	m^3		m^3	m^3		
LARGE MOBILE TOWER YARDERS										N
364	460	-	490-1050	490-1050	1.96	66	3.8	250	North America West Coast	CUG
377	400	-	-	86	-	-	-	55	Southeast Asia	SeH
	400	-	-	130	-	-	-	120	"	SeH
428	120	-	560	560	1.08	39	2.8	110	North America West Interior	CUH
	135	-	378	378	0.79	70	1.6	115	"	CUH
717	230	-	200-1000	200-1000	0.83	-	-	180	North America West Coast	CUH
RUNNING SKYLINE WING YARDERS										I
234	150	-	402	402	0.88	-	-	135	North America West Interior	CUDGr
249	185	10	879	-	0.92	87	1.8	155	North America West Coast	PUCh
	100	-	420	420	0.85	191	0.98	190	North America West Interior	CUDGr
428	180	-	250-950	250-950	0.97	-	-	215	North America West Coast	CUDGrNi
	170	-	250-950	250-950	0.74	-	-	140	"	CUDGrNi

Explanation of "Notes" Abbreviations in Table 13

I = Including moving time within the operating unit

N = Not including moving, set-up and take-down time

T = Thinning

P = Partial Cut

Se = Selective Cut

C = Clearcut

U = Uphill yarding

D = Downhill yarding

H = Highlead

R = Running skyline

S = Standing skyline

L = Live skyline

G = Live skyline (Gravity)

Ch = Chokers

Gr = Grapple

Ni = Night logging included in about 50 % of shifts

Cu = Cutting and limbing are included in the operations (cutting and limbing are not included in other examples)

EXAMPLES OF CABLE LOGGING EQUIPMENT

Classification: INDEPENDENT BUNCHING WINCHES

Manufacturer:	KMF Egger GmBH	Kolpe-Patent	Kolpe-Patent	Nordfor
Model:	Ackja 421	Radio-Tir 740	Radio-Tir Alpin	Flying Saucer
Maximum Pulling Power-Skyline	-	-	-	-
" " " -Mainline	8 kN (800 kp)	8 kN (800 kp)	12 kN (1 200Kp)	15 kN (1 500 kp)
" " " -Haulback	-	-	-	-
Maximum Line Speed -Skyline	-	-	-	-
" " " -Mainline	0.8 m/s	0.6 m/s	0.6 m/s	0.6 m/s
" " " -Haulback	-	-	-	-
Maximum Drum Capacity-Skyline	-	-	-	-
" " " -Mainline	120m x 7.5mm	150m x 6.0mm	165m x 7.0mm	125m x 6.5mm
" " " -Haulback	-	-	-	-
Tower Height	-	-	-	-
Engine Power	4.4kW (6hp)	4.4kW (6hp)	6kW (8hp)	12kW (16hp)
Weight of Complete Unit	70 kg	150 kg	270 kg	450 kg
		Radio control	Radio control	Radio control

EXAMPLES OF CABLE LOGGING EQUIPMENT

Classification: INDEPENDENT BUNCHING WINCHES

Manufacturer:	Theissen	Modern Logging
Model:	TW 70	
Maximum Pulling Power–Skyline	–	–
" " " –Mainline	15 kN	40 kN
	(1 500 kp)	(4 100 kp)
" " " –Haulback	–	–
Maximum Line Speed – Skyline	–	–
" " " –Mainline	1.5 m/s	0.6 m/s
" " " –Haulback	–	–
Maximum Drum Capacity–Skyline	–	–
" " " –Mainline	250m x 6.0mm	96m x 9.5mm
" " " –Haulback	–	–
Tower Height	–	–
Engine Power	11kW (15hp)	35kW (47hp)
Weight of Complete Unit	170 kg	730 kg
		Radio control

EXAMPLES OF CABLE LOGGING EQUIPMENT

Classification: MACHINE-MOUNTED WINCHES

Manufacturer:	Reinhardt	Kolpe-Patent	Nordfor	OSA
Model:	Drabant Winch	Tractor Winch	Tilt Winch	81G
Maximum Pulling Power - Skyline	-	-	-	-
" " " - Mainline	12 kN (1 200 kp)	15 kN (1 500 kp)	15 kN (1 500 kp)	18 kN (1 800 kp)
" " " - Haulback	-	-	opt. 4 kN (400 kp)	-
Maximum Line Speed - Skyline	-	-	-	-
" " " - Mainline	1.0 m/s	1.2 m/s	1.2 m/s	1.8 m/s
" " " - Haulback	-	-	opt. 5.0 m/s	-
Maximum Drum Capacity - Skyline	-	-	-	-
" " " - Mainline	40m x 8 mm	165m x 7.0 mm	250m x 7.0 mm	50 or 250m x 8 mm
" " " - Haulback	-	-	opt.800m x 4.0 mm	-
Tower Height	-	-	3.2 m	variable x)
Engine Power required	13.4kW (18hp)	29kW (40hp)	22kW (30hp)	11kW (15hp)
Weight of Complete Unit (Winch)		140 kg	900 kg	300 or 370 kg
Number of Drums	1	1	1 or 2	1
		Radio control	Radio control	Radio control

x) mounted on forwarder crane arm

EXAMPLES OF CABLE LOGGING EQUIPMENT

Classification: MACHINE-MOUNTED WINCHES

Manufacturer:	Igland	OSA	Igland	Gafner
Model:	Special 4000/4	101	Compact 5000/2H	Mini-Skidder
Maximum Pulling Power – Skyline	–	–	–	–
" " " – Mainline	39 kN (4 000 kp)$^{x)}$	44 kN (4 500 kp)	49 kN (5 000 kp)$^{x)}$	56 kN (5 700 kp)
" " " – Haulback	–	–	–	–
Maximum Line Speed – Skyline	–	–	–	–
" " " – Mainline	1.2 m/s $^{x)}$	1.6 m/s	1.8 m/s $^{x)}$	1.0 m/s
" " " – Haulback	–	–	–	–
Maximum Drum Capacity – Skyline	–	–	–	–
" " " – Mainline	30m x 11 mm$^{x)}$	75m x 10 mm	250m x 8mm$^{x)}$	38m x 14.3mm
" " " – Haulback	–	–	–	–
Tower Height	variable	–	variable	–
Engine Power required	up to 71kW (95hp)	30kW (41hp)	up to 67kW (90hp)	34 kW (45hp)
Weight of Complete Unit (Winch)	360 kg	170 kg	300 kg	
Number of Drums	4	1	2	1

optional Radio control

x) each drum

EXAMPLES OF CABLE LOGGING EQUIPMENT

Classification: MACHINE-MOUNTED WINCHES

Manufacturer:	Sepson	Clark	Caterpillar	Timberjack
Model:	18–20	664B Skidder	518 Skidder	550 Skidder
Maximum Pulling Power – Skyline	–	–	–	–
" " " – Mainline	88 kN (9 000 kp) x)	89 kN (9 100 kp)	142 kN (14 500 kp)	179 kN (18 200 kp)
" " " – Haulback	–	–	–	–
Maximum Line Speed – Skyline	–	–	–	–
" " " – Mainline	1.3 m/s x)	2.0 m/s	1.2 m/s	1.4 m/s
" " " – Haulback	–	–	–	–
Maximum Drum Capacity – Skyline	–	–	–	–
" " " – Mainline	50m x 16 mm x)	150m x 12.7 mm	72m x 16 mm	
" " " – Haulback	–	–	–	–
Tower Height	–	–	–	–
Engine Power required	up to 121 kW (165hp)	67kW (90hp)	89kW (120hp)	138kW (185hp)
Weight of Complete Unit (Winch)	785 kg			
Number of Drums	2	1	1	1

x) each drum

EXAMPLES OF CABLE LOGGING EQUIPMENT

Classification: MACHINE-MOUNTED WINCHES

Manufacturer:	Clark	Komatsu	Caterpillar	Komatsu
Model:	880 Skidder	D60E Crawler	D9H Crawler	D155A Crawler
Maximum Pulling Power – Skyline	–	–	–	–
" " " – Mainline	307 kN	449 kN	503 kN	693 kN
	(31 300 kp)	(50 900 kp)	51 300 kp)	(70 600 kp)
" " " – Haulback	–	–	–	–
Maximum Line Speed – Skyline	–	–	–	–
" " " – Mainline	1.7 m/s	0.9 m/s	0.6 m/s	0.7 m/s
" " " – Haulback	–	–	–	–
Maximum Drum Capacity – Skyline	–	–	–	–
" " " – Mainline	55m x 28.6 mm	90m x 26 mm	69m x 28 mm	90m x 26 mm
" " " – Haulback	–	–	–	–
Tower Height	–	–	–	–
Engine Power required	229 kW (307hp)	116kW (155hp)	306kW (410hp)	239kW (320hp)
Weight of Complete Unit (Winch)		1 280 kg	1 520 kg	1 850 kg
Number of Drums	1	1	1	1

EXAMPLES OF CABLE LOGGING EQUIPMENT

Classification: YARDERS

Manufacturer:	Iwate-Fuji	Vinje	Wyssen	Hinteregger
Model:	Y-12E	K-1200	W-20	Universal Winch -FSW 700
Maximum Load Capacity	–	2 000 kg	2 500 kg	–
Maximum Pulling Power–Skyline	12 kN x) (1 200 kp)	39 kN (4 000 kp)	43 kN (4 400 kp)	49 kN (5 000 kp)
" " " –Mainline	12 kN (1 200 kp)	20 kN (2 000 kp)	same as Skyline	same as Skyline
" " " –Haulback	12 kN (1 200 kp)	–	–	–
Maximum Line Speed –Skyline	3.5 m/s x)	–	–	–
" " " –Mainline	3.5 m/s	3.8 m/s	4.4 m/s	6.0 m/s
" " " –Haulback	3.5 m/s	–	–	–
Maximum Drum Capacity–Skyline	– x)	1 200m x 18mm	–	2 400m x 10mm
" " " –Mainline	820m x 8mm	2 500m x 10mm	1 800m x 9.5mm	–
" " " –Haulback	820m x 8mm	–	–	–
Tower Height	–	–	–	–
Engine Power	9kW (12hp)	44 to 74kW (60 to 100hp)	12kW(16hp)	38 or 51kW (52 or 70hp)
Weight of Complete Unit	850 kg (engine not included)	4 000 kg	860 kg	2 200 kg
Application	Gravity + All-Terrain	All-Terrain	Gravity + All-Terrain	Gravity + All-Terrain
Carrier	Skids	Trailer	Skids	Skids

x) Endless Drum

EXAMPLES OF CABLE LOGGING EQUIPMENT

Classification: YARDERS

Manufacturer:	Iwate Fuji	Nesler	Baco	Wyssen
Model:	Y-52E	MSA 4	SW and SWU 80L	W-200
Maximum Load Capacity	-	-	-	12 000 kg
Maximum Pulling Power-Skyline	50 kN (5 100 kp)x)	69 kN (7 000 kp)	98 kN (10 000 kp)	147 kN (15 000 kp)
" " " -Mainline	50 kN (5 100 kp)	same as Skyline	same as Skyline	same as Skyline
" " " -Haulback	40 kN (4 100 kp)	-	-	-
Maximum Line Speed -Skyline	7.3 m/sx)	-	-	-
" " " -Mainline	7.3 m/s	8.2 m/s	10.0 m/s	9.5 m/s
" " " -Haulback	9.2 m/s	-	-	-
Maximum Drum Capacity-Skyline	- x)	-	-	-
" " " -Mainline	1 530m x 12mm	2 200m x 14mm	2 000m x 16mm	4 200m x 16mm
" " " -Haulback	2 050m x 12mm	-	-	-
Tower Height	-	-	-	-
Engine Power	69kW (92hp)	149kW (200hp)	110kW (150hp)	149kW (200hp)
Weight of Complete Unit	5 000 kg	4 700 kg	4 500 kg	6 800 kg
Application	Gravity + All-Terrain	Gravity + All-Terrain	Gravity + All-Terrain	Gravity + All-Terrain
Carrier	Skids	Skids	Skids	Skids

x) Endless Drum

EXAMPLES OF CABLE LOGGING EQUIPMENT

Classification: YARDING TRAILERS FOR CONTINUOUS MAINLINE SYSTEM

Manufacturer:	Steyr
Model:	Timber-veyor
Maximum Load Capacity	-
Maximum Pulling Power-Skyline	-
" " " -Mainline	59 kN (6 000kp)
" " " -Haulback	-
Maximum Line Speed -Skyline	-
" " " -Mainline	1.4 m/s
" " " -Haulback	-
Maximum Yarding Distance	400 m
"Tower" Height	4 m
Engine Power	88kW (120hp)
Weight of Complete Unit	14 000 kg
Carrier	Truck

EXAMPLES OF CABLE LOGGING EQUIPMENT

Classification: MOBILE TOWER YARDERS-Small: Up to 100 kN (10 200 kp) pulling power on mainline

Manufacturer: Model:	Hinteregger I-Mini-Urus	Igland Alp Winch	James Jones Highland Alp	Hinteregger IV-Urus Gigant
Maximum Load Capacity	600 kg	1 000 kg	1 500 kg	2 000 kg
Maximum Pulling Power-Skyline	98 kN (10 000 kp)	49 kN (5 000 kp)	-	196 kN (20 000 kp)
" " " -Mainline	15 kN (1 500 kp)	49 kN (5 000 kp)	-	49 kN (5 000 kp)
" " " -Haulback	15 kN (1 500 kp)	49 kN (5 000 kp)	-	49 kN (5 000 kp)
Maximum Line Speed -Skyline				
" " " -Mainline	8.0 m/s	5.0 m/s	4.6 m/s	7.6 m/s
" " " -Haulback		5.0 m/s	4.6 m/s	
Maximum Drum Capacity-Skyline	330m x 13.0mm	800m x 18mm	650m x 16mm	530m x 25mm
" " " -Mainline	350m x 6.5mm	800m x 8mm	800m x 9mm	500m x 14mm
" " " -Haulback	650m x 6.5mm	800m x 8mm plus 800m x 10mm=1 600m	800m x 9mm	1 050m x 14mm
Tower Height	4.7 m	8.0 m	7.2 m	9.6 m
Engine power	19 to 30 kW (25 to 40 hp)	up to 56 kW (75 hp)	37 to 60 kW (50 to 80 hp)	112 to 186 kW (150 to 250 hp)
Weight of Complete Unit	2 200 kg (without engine)	4 200 kg	4 200 kg	17 700 kg
Carrier x)	Trailer	Trailer	Trailer	Truck

x) Truck: Self-propelled

Trailer: Must be pulled by another machine (trailer is on rubber tires)

EXAMPLES OF CABLE LOGGING EQUIPMENT

- Classification: MOBILE TOWER YARDERS-Small: Up to 100 kN (10 200 kp) pulling power on mainline

Manufacturer:	Koller	Koller
Model:	Modif. K 800	K 800
Maximum Load Capacity	-	2 500 kg
Maximum Pulling Power-Skyline	97 kN (9 900 kp)	98 kN (10 000 kp)
" " " -Mainline	53 kN (5 400 kp)	58 kN (5 900 kp)
" " " -Haulback	53 kN (5 400 kp)	36 kN (3 700 kp)
Maximum Line Speed -Skyline	2.0 m/s	1.0 m/s
" " " -Mainline	6.2 m/s	4.8 m/s
" " " -Haulback	6.2 m/s	7.5 m/s
Maximum Drum Capacity-Skyline	750m x 24 mm	750m x 24mm
" " " -Mainline	750m x 12 mm	1 150m x 12mm
" " " -Haulback	750m x 12 mm	750m x 12mm
Tower Height	10.0 m	10.0 m
Engine Power	111kW (149hp)	150kW (205hp)
Weight of Complete Unit	10 000 kg	10 000 kg
Carrier x)	Truck	Truck

x) Truck: Self-propelled

Trailer: Must be pulled by another machine (trailer is on rubber tires)

EXAMPLES OF CABLE LOGGING EQUIPMENT

Classification: MOBILE TOWER YARDERS - Medium: over 100 kN (10 200 kp) and up to 300 kN (30 600 kp) pulling power on mainline

Manufacturer:	Rosedale	Steyr	Forestral/Unitec	Rosedale
Model:	Eco I	KSK 16	Little Giant	Sidewinder
Maximum Pulling Power-Skyline	-	270 kN (27 500 kp)	opt. 178 kN (18 100 kp)	481 kN (49 000)
" " " -Mainline	111 kN (11 300 kp)	152 kN (15 500 kp)	178 kN (18 100 kp)	178 kN (18 100 kp)
" " " -Haulback	111 kN (11 300 kp)	102 kN (10 350 kp)	156 kN (15 900 kp)	178 kN (18 100 kp)
Maximum Line Speed -Skyline	-	9.7 m/s	opt. 4.4 m/s	8.6 m/s
" " " -Mainline	5.1 m/s	9.9 m/s	4.4 m/s	15.2 m/s
" " " -Haulback	5.1 m/s	9.9 m/s	5.2 m/s	15.2 m/s
Maximum Drum Capacity-Skyline	-	1 450m x 16mm	opt.240m x 17.5mm	910m x 25.4mm
" " " -Mainline	380m x 17.5mm	1 250m x 10mm	240m x 17.5mm	790m x 19.0mm
" " " -Haulback	550m x 14.3mm	1 250m x 10mm	610m x 15.9mm	1 200m x 19.0mm
Tower Height	12.8 m	16-20 m	12.8 m	13.7 m
Engine Power	up to 104kW (140hp)	186kW (250hp)	90kW (120hp)	239kW (320hp)
Weight of Complete Unit	14 100 kg	28 500 kg	14 500 kg	47 200 kg
Carrier x)	Skidder, Track or Truck	Truck	Skidder or Track	Track
	opt. Radio control		Radio control	Swing Yarder

x) Truck: Self-propelled

Skidder: Self-propelled

Track: Self-propelled (can be tank or crawler tracks)

EXAMPLES OF CABLE LOGGING EQUIPMENT

Classification: MOBILE TOWER YARDERS–Medium: over 100 kN (10 200 kp) and up to 300 kN (30 600 kp) pulling power on mainline

Manufacturer:	Madill	Forestral/Unitec
Model:	West Coast Tower	Little Giant
Maximum Pulling Power–Skyline	391 kN (39 900 kp)	opt. 267 kN (27 200 kp)
" " " –Mainline	251 kN (25 600 kp)	267 kN (27 200 kp)
" " " –Haulback	221 kN (22 500 kp)	200 kN (20 400 kp)
Maximum Line Speed –Skyline		opt. 5.1 m/s
" " " –Mainline	7.2 m/s	5.1 m/s
" " " –Haulback	8.3 m/s	7.1 m/s
Maximum Drum Capacity–Skyline	590m x 25.4mm	opt. 270m x 23.8mm
" " " –Mainline	820m x 15.9mm	270m x 23.8mm
" " " –Haulback	1 280m x 12.7mm	550m x 20.6mm
Tower Height	14.6 m	18.3 m
Engine Power	212 kW (284hp)	138 kW (185hp)
Weight of Complete Unit	33 300 kg	
Carrier x)	Track	Skidder or Track
		Radio control

x) Truck: Self-propelled

Skidder: Self-propelled

Track: Self-propelled (can be tank or crawler tracks)

EXAMPLES OF CABLE LOGGING EQUIPMENT

Classification: MOBILE TOWER YARDERS-Large: over 300 kN (30 600 kp) pulling power on mainline

Manufacturer:	Skagit	Berger	Berger	Skookum
Model:	BU-737+T-90	Marc II R	Marc I	K-114D5+M10
Maximum Pulling Power-Skyline	542 kN (55 200 kp)	667 kN (68 000 kp)		534 kN (54 400 kp)
" " " **-Mainline**	opt. 349 kN xx) (35 600 kp)	373 kN (38 000 kp)	378 kN (38 500 kp)	378 kN (38 500 kp)
" " " **-Haulback**	422 kN (43 000 kp)	304 kN (31 000 kp)	142 kN (14 500 kp)	178 kN (18 100 kp)
Maximum Line Speed -Skyline	7.8 m/s	5.0 m/s	-	7.6 m/s
" " " **-Mainline**	7.1 m/s	12.1 m/s	5.1 m/s	10.7 m/s
" " " **-Haulback**	10.3 m/s	15.2 m/s	9.2 m/s	21.8 m/s
Maximum Drum Capacity-Skyline	510m x 28.6mm	670m x 34.9mm	-	700m x 34.9mm
" " " **-Mainline**	850m x 15.9mm	670m x 25.4mm	410m x 28.6mm	670m x 28.6mm
" " " **-Haulback**	1390m x 19.0mm	1460m x 22.2mm	910m x 19.0mm	1680m x 22.2mm
Tower Height	27.4 m	33.5 m	15.2 m	36.6 m
Engine Power	283kW (380hp)	317kW (425hp)	224kW (300hp)	373kW (500hp)
Weight of Complete Unit	52 200-57 500 kg	79 700 kg	40 000 kg	
Carrier x)	Rubber, Track or Trailer	Rubber	Track	Track

x) **Rubber:** Self-propelled

Track: Self-propelled (can be tank or crawler tracks)

Trailer: Must be pulled by another machine (trailer is on rubber tires)

xx) "Mainline" drum is optional. In the two drum version the "Skyline" drum above becomes the "Mainline" drum.

EXAMPLES OF CABLE LOGGING EQUIPMENT

Classification: MOBILE TOWER YARDERS-Large: over 300 kN (30 600 kp) pulling power on mainline

Manufacturer:	Madill	Washington	Skagit	Washington
Model:	009-3+"S"Tower	127W+T90	BU-199+T-110	208-110
Maximum Pulling Power-Skyline	-	-	829 kN (84 500 kp)	1 201 kN (122 400 kp)
" " " -Mainline	596 kN (60 800 kp)	609 kN (62 100 kp)	673 kN (68 600 kp)	1 201 kN (122 400 kp)
" " " -Haulback	221 kN (22 500 kp)	226 kN (23 000 kp)	244 kN (24 900 kp)	846 kN (86 200 kp)
Maximum Line Speed -Skyline	-	-	7.7 m/s	9.4 m/s
" " " -Mainline	5.6 m/s	7.0 m/s	9.8 m/s	9.0 m/s
" " " -Haulback	15.3 m/s	15.0 m/s	27.9 m/s	13.3 m/s
Maximum Drum Capacity-Skyline	-	-	850m x 38.1mm	670m x 34.9mm
" " " -Mainline	430m x 32mm	430m x 31.8mm	790m x 34.9mm	610m x 31.8mm
" " " -Haulback	1040m x 22mm	1020m x 22.2mm	1520m x 25.4mm	1360m x 29.0mm
Tower Height	28.5 m	28.3 m	33.5 m	34.4 m
Engine Power	224 to 410 kW (300 to 550hp)	250 to 319 kW (335 to 428hp)	395 kW (530hp)	373 kW (500hp)
Weight of Complete Unit	52 000 to 61 000kg	55 000kg(Trailer)	85 400-110 200kg	82 600 kg
Carrier x)	Rubber, Track or Trailer	Rubber, Track or Trailer	Rubber or Trailer	Rubber

x) Rubber: Self-propelled

Track: Self-propelled (can be tank or crawler tracks)

Trailer: Must be pulled by another machine (trailer is on rubber tires)

EXAMPLES OF CABLE LOGGING EQUIPMENT

Classification: RUNNING SKYLINE SWING YARDERS

Manufacturer:	Washington	Skagit	Berger	Pierce-Pacific
Model:	78 Skylok	GT-3	Marc V	PS4-200
Maximum Load Capacity	–	–	–	–
Maximum Pulling Power – Skyline	–	–	–	–
" " " – Mainline	234 kN (23 850 kp)	249 kN (25 400 kp)	267 kN (27 200 kp)	272 kN (27 700 kp)
" " " – Haulback	76 kN (7 700 kp)	152 kN (15 540 kp)	129 kN (13 200 kp)	162 kN (16 500 kp)
Maximum Line Speed – Skyline	–	–	–	–
" " " – Mainline	6.9 m/s	7.2 m/s	4.1 m/s	5.4 m/s
" " " – Haulback	7.6 m/s	11.6 m/s	4.1 m/s	8.9 m/s
Maximum Drum Capacity – Skyline	–	–	–	–
" " " – Mainline	550m x 12.7mm	520m x 15.9mm	670m x 22.2mm	640m x 19.0mm
" " " – Haulback	990m x 15.9mm	730m x 19.0mm	1 340m x 22.2mm	1 490m x 19.0mm
Tower Height	13.6 m	13.6 m	16.2 m	15.2 m
Engine Power	147kW (197hp)	164kW (220hp)	224kW (300hp)	340kW (456hp)
Weight of Complete Unit	40 100 kg	40 300–43 100 kg	68 200 kg	59 900 kg
Type of Carrier (self-propelled)	Track	Rubber – Track	Rubber	Rubber

EXAMPLES OF CABLE LOGGING EQUIPMENT

Classification: RUNNING SKYLINE SWING YARDERS

Manufacturer:	Washington	Madill	Skagit
Model:	118 Skylok	004 Yarding Crane	SY-747
Maximum Load Capacity	-	-	-
Maximum Pulling Power - Skyline	-	-	-
" " " - Mainline	386 kN (39 300 kp)	474 kN (48 300 kp)	533 kN (54 300 kp)
" " " - Haulback	111 kN (11 300 kp)	525 kN (53 500 kp)	415 kN (42 300 kp)
Maximum Line Speed - Skyline	-	-	-
" " " - Mainline	7.3 m/s	15.0 m/s	9.0 m/s
" " " - Haulback	9.0 m/s	15.1 m/s	11.9 m/s
Maximum Drum Capacity - Skyline	-	-	-
" " " - Mainline	490m x 22.2mm	540m x 25.4mm	820m x 25.4mm
" " " - Haulback	1 010m x 22.2mm	1 370m x 15.9mm	1 070m x 22.2mm
Tower Height	17.1 m	18.3 m	15.2 m
Engine Power	237kW (318hp)	336kW (450hp)	317kW (425hp)
Weight of Complete Unit	51 700-53 500 kg	74 800-89 600 kg	51 300 kg
Type of Carrier (self-propelled)	Track - Rubber	Rubber - Track	Rubber

EXAMPLES OF CABLE LOGGING EQUIPMENT

Classification: CARRIAGES

Manufacturer:	James Jones	Wyssen	Koller	Vinje
Model:	Traveling Block	Automatic	SKA & ASKA 2.5	K-1200
Maximum Load Capacity		2 000 kg	2 500 kg	2 000 kg
Maximum Pulling Power-Skidding line				
Size of -Skyline	18 mm	31.8 mm	18-32.0 mm	18 mm
" " -Mainline	9-11 mm	15.9 mm	10-12.5 mm	10 mm
" " -Skidding line	9-11 mm	15.9mm Mainline-Gravity 170m x 15.9mm - All-Terrain	10-12.5 mm	75m x 10 mm
Engine Power	-	-	-	-
Weight of Carriage	13 kg	230 kg - Gravity 380 kg - All-Terrain	250 kg	250 kg
" " Carriage Stops	-	-	-	160 kg
Application	All-Terrain	Gravity or All-Terrain	Gravity or All-Terrain	All-Terrain
Position Holding	Operating Lines	Clamp	Clamp(s)	Carriage Stop
Slackpulling	Manual	Manual or Operating Lines	Manual or Operating Lines	Operating Lines
				Radio Control

EXAMPLES OF CABLE LOGGING EQUIPMENT

Classification: CARRIAGES

Manufacturer:	Mar	Igland	Danebo	Berger
Model:	303 Grapple Carriage	Alp Winch	M-20	C-4
Maximum Load Capacity				
Maximum Pulling Power-Skidding Line				
Size of -Skyline	-	18 mm	19 - 22.2mm	38.1mm
" " -Mainline	19.0 - 25.4mm	8 mm	19 - 22.2mm	28.6mm
" " -Skidding Line	19.0 - 25.4mm	100m x 8mm	19 - 22.2mm	28.6mm
Engine Power	-	-	-	-
Weight of Carriage	Carriage 260 kg (grapples = +500 kg)	280 kg	455 kg	590 kg
" " Carriage Stops	-	56 kg	-	-
Application	Up - & Downhill	All-Terrain	Gravity	Up - & Downhill
Position Holding	Operating Lines	Carriage Stop	Clamp	Operating Lines
Slackpulling	Operating Lines	Operating Lines	Manual	Operating Lines

EXAMPLES OF CABLE LOGGING EQUIPMENT

Classification: CARRIAGES

Manufacturer:	Baco	Rosedale	Berger	Young
Model:	BK50-6R	Sky Hawk	C-5	SR-75
Maximum Load Capacity	5 000 kg			
Maximum Pulling Power-Skidding Line				
Size of -Skyline	28 - 34 mm	22.2-31.8mm	34.9mm	28.6-41.3mm
" " -Mainline	16 - 19 mm	19 mm	22.2mm	-
" " -Skidding Line	16 - 19 mm	90m x 19mm (Mainline)	Chokers	Chokers
Engine Power	-	-	-	-
Weight of Carriage	750 kg	1 270 kg	1 300 kg	1 630 kg
" " Carriage Stops	-	-	-	-
Application	Gravity	Gravity	Gravity	Gravity
Position Holding	Clamp	Clamp	Operating Lines	Clamp
Slackpulling	Manual	Carriage	-	-
		Radio Control		Radio Control

EXAMPLES OF CABLE LOGGING EQUIPMENT

Classification: CARRIAGES

Manufacturer:	Hinteregger	Skagit	Esco	Esco
Model:	Hibamat 8t	RCC-15	Bantam - 2 Drop Butt Rigging	Standard-3 Drop Butt Rigging
Maximum Load Capacity	8 000 kg - carriage 12 000 kg - with load beam			
Maximum Pulling Power-Skidding Line		20 000 kp		
Size of -Skyline	35 - 40 mm	34.9 - 50.8mm	-	-
" " -Mainline	15 - 18 mm	-	Max. 19 mm	Max. 38 mm
" " -Skidding Line	120m x 18-20 mm	135m x 22.2mm	Chokers	Chokers
Engine Power	-	71kW (95hp)	-	-
Weight of Carriage	1 900 kg	3 100 kg	67 kg	450 kg
" " Carriage Stops	-	-	-	-
Application	All-Terrain	Gravity or Up - & Downhill	Highlead	Highlead
Position Holding	Clamp	Clamp	Operating Lines	Operating Lines
Slackpulling	Operating Lines	Carriage Radio Control	-	-

APPENDIX 2

A. UNITS OF MEASURE

The units of measure used in this compendium are according to Système International d'Unités (The International System of Units) which is an internationally determined system of measurement units. This system is based upon the previous metric system.

hp (horsepower) - See kW below.

kN (kiloNewton, or thousand Newtons) - One Newton is the force required to give a mass of one kilogram an acceleration of one meter per second squared.

1 N = 0.102 kp

kp (kilopond) - One kilopond is the gravity force on the mass of one kilogram at sea level. kp is the same as kgf (kilogram force). Many manufacturers use kg (without the f) as an expression of pulling power. North American manufacturers use pounds (lbs) as an expression of pulling power. The following relationship can be used:

2.205 lbs = 1 kg = 1 kgf = 1 kp

1 kp = 9.81 N

m/s (metres per second) - m/s x 60 = metres per minute

m/s x 60 x 3.28 = feet per minute

m (metre) - 1 metre = 3.28 feet

kW (kilowatt) - One watt is an effect equal to one joule per second.

1 horsepower (metric) ≈ 735.5 W = 0.7355 kW

or

1 horsepower ≈ 745.7 W = 0.7457 kW

B. TERMINOLOGY

Important cable logging terms which may be new to the reader are described below. Terms which are not included here are described in the main text.

BACKSPAR	See Tailspar
BLOCK	A metal case, enclosing one or more pulleys, used to lead a line in a specific direction (see Figure 4).
BUNCH	To assemble logs together to form a load for subsequent transport.
BUTT RIGGING	The chain and swivels which connect the mainline and haulback line in the highlead and other logging systems. Logs are attached to the butt rigging with chokers for yarding (see Figure 43).
CABLE CONFIGURATION	A set of cables, carriers and other cableway accessories excluding yarding machine(s) as a power supply.
CABLE LOGGING SYSTEM	A yarding system consisting of a power supply, cables, carriers and other cable crane accessories.
CARRIAGE	(Sometimes called Skyline Crane). The unit which travels along and is suspended above the ground by the skyline. Logs are attached to the carriage or to the skidding line for yarding. A carriage may or may not use a skidding line (see Figures 37 through 42, and 44 through 47).
CARRIAGE CLAMP	See Clamp.
CHASER	The person who unhooks the choker from the logs at the landing.
CHOKER	The cable (wire rope) which is fastened around the logs so that they can be transported to a landing. Chokers are attached to the butt rigging, carriage or skidding line.
CHOKERMAN	A person who attaches the chokers to the logs.
CHOKERSETTER	See Chokerman.
CLAMP	1. a device to hold a carriage in position on the skyline. Also called Carriage Clamp. 2. a device to hold wire ropes together, which is generally used in fastening a skyline to the anchor(s). Also called Skyline Clamp.
CONTROL LINE	An operating line to control dynamically the tension of other operating line(s) or skyline.
CORRIDOR	A cleared strip through which a skyline or a line functioning like a skyline is operated (also called a Skyline Corridor, or Skyline Strip).
CYCLE	A complete set of operations or tasks that is repeated (see also Turn).
DECK	A stack or pile of logs; or to stack logs.
DEFLECTION	See Skyline Deflection.
DRUMS	See Operating Drums.

FALLBLOCK	(Also called Loading Block). An almond-shaped block used for loading in cable systems (see Figure 18).
GRAPPLE	A hinged set of jaws capable of being opened and closed, used to grip logs. Metal tongs. Such tongs can be fastened to a slack-pulling carriage for use in the running skyline or a live skyline configuration.
GRAPPLE LOGGING	The use of grapples on a slack-pulling carriage with a running skyline swing yarder has become popularly known as grapple logging (see Figure 47).
GUYLINE	The cable (wire rope) used to steady an object. In this compendium it most often refers to the cable(s) used to stabilize a tower (or spar trees) so that forces against that tower do not pull it over.
HANG-UP	The situation when the yarding process is stopped or impeded due to an obstacle (stump, rock etc.).
HAULBACK	The cable (wire rope) which is used to pull the butt rigging or carriage out to the operating area.
HOOK	1. To attach chokers or other rigging devices to logs on the ground. 2. a curved member used to catch, hold or pull something.
INTERMEDIATE SUPPORT	The support between two spans on a standing skyline over which a multispan skyline carriage can pass. Intermediate supports are placed at critical locations along the skyline in order to give the skyline the required clearance above the ground (see Figures 9, 10 and 11).
LANDING	The collection point to which the logs are brought following yarding. A landing can be at a road, railroad or in the operating area. If the landing is not at a road, additional yarding (swinging) to a landing at the road will be necessary.
LEAD	The direction of the line of haul.
LOADING BLOCK	See Fallblock.
MAINLINE	The cable (wire rope) which is used to pull the butt rigging or carriage in to the landing.
MULTISPAN SKYLINE	A skyline which has more than one span (Figures 10 and 11).
MULTISPAN SKYLINE CARRIAGE	A carriage, normally a skyline crane, which can pass over intermediate supports (see Figures 38 through 42).
OPEN-FACED BLOCK	A block used to hold the continuous mainline. It is so constructed that operating lines with chokers, or other small rigging with logs, can pass through or by it (see Figure 23).
OPERATING DRUMS	The winch drums on the yarder which control the movements of the operating lines and upon which the operating lines are wound.

OPERATING LINES	Those cables (wire ropes), usually wound on drums, which perform a function during the yarding cycle. The haulback line, mainline and slack-pulling line are operating lines. The skyline is sometimes considered as an operating line. The strawline is normally not considered an operating line as it is normally only used for laying out and changing yarding strips. If the strawline is used during the yarding cycle, e.g. for side blocking, it then becomes an operating line.
ROAD	The path followed by a turn of logs skidded or yarded by a cable system (also called Yarding Road).
SIDE BLOCKING	A method of increasing the yarding strip by pulling the operating lines to the side with another line. The strawline can be used for this purpose.
SINGLE SPAN SKYLINE	A skyline which has only one span (see Figures 17 through 22).
SINGLE SPAN SKYLINE CARRIAGE	A carriage which cannot pass over intermediate supports (see Figures 37, and 44 through 47).
SKIDDING	The process of pulling the logs to the carriage prior to transporting them along the skyline, or pulling them by the mainline.
SKIDDING LINE	The cable (wire rope) which is used for pulling the logs to the carriage. The logs are usually attached to the skidding line with chokers. If the line is also used to haul the logs it is called the mainline. Some carriages have internal drums for the skidding line (see Figures 18, 19, and 37 through 39; and 41, 42 and 45).
SKYLINE	The line from which the carriage is suspended in order to keep the carriage above the ground. The carriage travels back and forth along the skyline (see Figures 10, 11, 12, 17 through 21, 33, 34, 37 through 42, 44 through 48).
SKYLINE CLAMP	See Clamp.
SKYLINE CORRIDOR	See Corridor.
SKYLINE CRANE	(Sometimes called Carriage). A carriage to which logs can be pulled through the use of a skidding line (see Figures 37, 38, 39, 41, 42 and 45). The carriages in Figures 44 and 47 are not skyline cranes. This term is not to be confused with the term "Cable Crane" which is something used to collectively denote an entire cable logging system, e.g. multispan cable crane system.
SKYLINE DEFLECTION	The vertical distance between the skyline and the chord of the skyline (see Figure 48).
SKYLINE ROAD	The entire area that is yarded from a skyline strip. This includes the area adjacent to the skyline strip from which the logs or trees are skidded to the skyline.
SKYLINE STRIP	The strip (clearcut strip in a thinning or partial cut) or corridor where the skyline is suspended. It is along this strip that the carriage travels during yarding.
SKYLINE TENSION	The longitudinal force or strain on the skyline.

SLACKPULLING LINE	An operating line which is used to control and operate the carriage skidding line or grapple line (see Figure 47).
SPAN	The horizontal distance between two supports and/or anchor points and/or blocks of a skyline (see Figure 48).
SPAR (WOODEN)	A large tree trunk which is usually supported vertically by guylines and from which blocks are hung in order to elevate the operating lines.
STANDING SKYLINE	A skyline anchored at both ends.
STRAWLINE	The small cable (wire rope) which is usually used for laying out and changing yarding strips, stringing heavier lines, (See also Operating Lines).
SWINGING	The process of moving logs from one landing to another.
TAILBLOCK	The block which is placed at the farthest point to which the haulback line must travel along the yarding strip (see Figures 16 and 35). The haulback line travels through this block.
TAILHOLD	The object to which the tailblock is fastened (i.e. stump, tractor, etc.) or the object to which the end of a skyline is anchored.
TAILSPAR	(Also called Backspar). The spar at the outer end of a system, away from the yarder.
TERRAIN TRANSPORTATION	The process of transporting logs or trees from the place at which they are cut to the road or landing.
TURN	The log(s) or tree(s) yarded during any single yarding cycle.
YARDER	A machine for yarding which includes the operating drum(s) and the power source required to operate the drum(s). (See Figure 13).
YARDING	The terrain transportation of logs or trees with a cable logging system.
YARDING ROAD	The entire area that is yarded from a yarding strip.
YARDING STRIP	The strip along which the logs travel (are transported) during yarding. In skyline systems this is often called the Skyline Strip.

REFERENCES

Aulerich, Ed and Kellog, Loren Pre-bunch and swing technique may reduce your thinning
1977 costs. Forest Industries, Feb., p. 30-32

B.C. Forest Service, Victoria. Duhamel Creek Skyline Logging. Report on 1974
1975 Operation. Feb. p-1-17

Bernhard, Alfred. Arbeitsstudien bei der Holzrückung mit dem Steyr-Kippmastseilkran
1979 KSK16. Allgemeine Forstzeitung, March, p.55-58

Bernhard, Alfred and Lenger, Adolf. Arbeitsstudien bei der Holzrückung mit mobilen
1974 Kippmast-Kurzstreckenseildränen. Allgemeine Forstzeitung, March. p.59-67.

Bernhard, Alfred and Lenger, Adolf and Lugmayr, Johannes. Arbeitsstudien bei der
1978 Vollbaumnutzung im Gebirge. Allgemeine Forstzeitung, Sept. p.305-308.

Binkley, Virgil W., and Studier, Donald D. Cable Logging Systems. U.S. Department
1974 of Agriculture, Forest Service, Div. of Timber Management 204 pp.

Binkley, Virgil W. and Sessions, John. Chain and Board Handbook for Skyline Tension
and Deflection. Forest Service, U.S. Department of Agriculture, Pacific
Northwest Region.

Brossman, L. AFZ-Thema. Schwachholz-Vorliefer Geräte. Allgemeine Forst Zeitschrift, 32.
1977 Jahrgang, Sept. 10, München, p.889-894.

Carson, Ward W. and Jorgenson, Jens E. Understanding Interlock Yarders. USDA Forest
1974 Service. Research Note, PNW-221, March. U.S. Department of Agriculture,
Portland, Oregon. Pacific Northwest Forest and Range Experiment Station.

Cottell, P.L. and McMorland, B.A. and Wellburn, G.V. Evaluation of Cable Logging Systems
1976 in Interior B.C. and Alberta. FERIC. Technical Report No. TR-8, Sept. p.1-41.

Dykstra, Dennis P. Production Rates and Costs for Cable, Balloon and Helicopter Yarding
1975 Systems in Old-Growth Douglas-fir. Forest Research Laboratory, School of
Forestry, Oregon State University. Research Bulletin 18, p-1-57.

Dykstra, Dennis P. Production Rates and Costs for Yarding by Cable, Balloon and
1976 Helicopter Compared for Clearcuttings and Particle Cuttings. Forest Research
Laboratory, School of Forestry, Oregon State University. Research Bulleting 22,
p. 1-44.

Edsberg, Arne. Tynningsdrift med kabelbane i Skottland (Thinning Operations with Cable Crane
1977 in Scotland). Norsk Skogbruk, No.6-7, p. 20, 26.

FAO. Análisis del Transporte Forestal Basada en el Sistema Cable Aéreo. Guatemala.
1977 FO:DP/GUA/72/006. Documento de Trabajo No.26, October, p. 1-28.

Joint FAO/ECE/ILO Committee on Forest Working Techniques and Training of Forest Workers.
1973 Symposium on Forest Operations in Mountainous Regions. Technical Report. U.N.
Geneva, September.

Fjalestad, Inge. Iglands alpevinsj. Norwegian Forest Research Institute, Driftsteknisk
1975 Rapport No.13, p.153-161.

Fraser, Hugh R. Endless Cable makes Thinning Profitable. World Wood, August, p.11-12, 19.
1976

Fraser, Hugh R. All-terrain skyline uses twin carriages. World Wood, September
1976 p.20-21.

Glossary of Forest Engineering Terms, U.S. Department of Agriculture, Forest Service, 24 pp.

Holzwieser, Othmar. Seilgeräteeinsatz im Rahmen der mechanisierten Holzernte bei den
1976 Oestorreichischen Bundesforsten. Allgemein Forstzeitung, 87. Jahrgang, Wien, Jänner, p.17-20.

Larsson, Torbjörn and Permalm, Henrik. Studie av vinschbrossling med Radiotirsystemet
1971 (Study of Winching by the Radiotir System). Logging Research Foundation, Sweden. Report No.7, p.1-27.

Leitner, Anton. Kombinierte Schlägerung - Seilkranlieferung bei Durchforstungen im
1976 Gebirge. Allgemeine Forstzeitung, 87. Jahrgang, Wien, Jänner, p.21-24

Lisland, Torstein. Cable Logging in Norway. Northeast Area Foundation Forestry Series,
1975 School of Forestry, Oregon State University, 52 pp.

Lisland, Torstein. Norwegische Seildräne und ihre Arbeitsverfahren. Allgemeine
1976 Forstzeitung, 87. Jahrgang, Wien, Jänner, p.11-15.

Lysons, Hilton H. and Mann, Charles N. Skyline Tension and Deflection Handbook, U.S.
1967 Department of Agriculture, Forest Service, Pacific Northwest Forest and Range Experiment Station, Research Paper PNW-39, 41 pp

Mann, Charles N. Why Running Skylines and Interlock Yarders? Skyline Logging Symposium
1976 Proceedings, Vancouver B.C. Dec. p.17-26. U.S. Department of Agriculture, Forest Service, Pacific Northwest Forest and Range Experiment Station.

Mann, Charles N. Mechanics of Running Skylines. Research Paper PNW-75, Portland, Oregon,
1969. U.S. Department of Agriculture, Pacific Northwest Forest and Range Experiment Station

O'Leary, John. Timber extraction to the roadside by use of cableways, in Technology of
1974 Forestry, being documentation of the scientific congress of Interforest '74, held in June in Munich.

Omnes, Harald Full-tree yarding with radio controlled cable crane and mechanized delimbing
1975 at the lower landing. The Norwegian Forest Research Institute, Driftsteknisk Rapport No.13, p.99-106

Samset, Ivar. Erection and operation of the Norwegian radio-controlled cable crane.
1969 Norwegian Forest Research Institute. Driftsteknisk Rapport No.7, p.41-74

Samset, Ivar and Lisland, Torstein. Østerrikske skogsdrifter i bratt terreng, Del I,
1977 Norsk Skogsbruk Nr. 10

Samset, Ivar and Lisland, Torstein. Østerrikske skogsdrifter i bratt terreng, Del II,
1977/78 Teknikk i Skogen. Norsk Skogsbruk, Nr. 9

Sessions, John. Carriage Design Affects the Payload of Skyline Logging Systems. Research
1977 Note No.58. School of Forestry, Oregon State University, Forest Research Laboratory 2 pp.

Sethi, Y.R. and Sood, K.G. Suitability and Economics of Baco Skyline Crane, Indian Forester,
1977 August, p. 525-535.

Logging with Skagit. Skagit Steel and Iron Works, Sedro Wooley, Washington, U.S.A. 13 pp.

Tennas, Magnus E. The Norwegian Forest Research Institute and Ruth, Robert H. and Bernsten,
1955 Carl M., Pacific Northwest Forest and Range Experiment Station. An Analysis of Production and Costs in Highlead Yarding. Research Paper No.11. U.S. Department of Agriculture, Forest Service. p. 1 - 37.

Trzesniowski, Anton. Die Ossiacher Akja-Seilwinde. Allgemeine Forstzeitung, 87. Jahrgang,
1976 Wien, Jänner. p.24-35.

Trzesniowski, Anton. Logging in the Mountains of Central Europe. FAO. Swedish Funds-in-
1976 Trust, FOI:TF-INT-74 (SWE). p. 1-34.

Vypel, Kurt. Entwicklung und Einsatz von Kippmast-Seilkränen zur Holzbringung. Allgemeine
1976 Forstzeitung, 87. Jahrgang, Wien, Jänner. p.8, 11.

Wettstein, R. Economic Layout of Cable Crane Systems. ECE/FAO/ILO LOG/SYMP.5/78.
1978

Willingshöfer, Kurt. Erfahrungsbericht über den Einsatz des neuen Seilkrans "Mini Urus" für
1978 Durchforstung im Schwachholz und mittleren Baumholz. Sonderdruch aus "Allgemeine stzeitschrift" No.18.

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